THE

EDINBURGH

PHILOSOPHICAL JOURNAL.

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PHILOSOPHICAL JOURNAL,

EXHIBITING A VIEW OF

THE PROGRESS OF DISCOVERY IN NATURAL PHILOSOPHY, CHEMISTRY, NATURAL HISTORY, PRACTICAL MECHANICS, GEOGRAPHY, NAVIGATION, STATISTICS, AND THE FINE AND USEFUL ARTS,

FROM

APRIL 1. TO OCTOBER 1. 1821.

CONDUCTED BY

DR BREWSTER AND PROFESSOR JAMESON.

TO BE CONTINUED QUARTERLY.

VOL. V.

EDINBURGH:
PRINTED FOR ARCHIBALD CONSTABLE AND COMPANY.

1821.

P. Neill, Printer.

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Art. I.—*On the Connexion between the Optical Structure and Chemical Composition of Minerals.* By David Brewster, LL. D. F. R. S. Lond. & Sec. R. S. E.

In the course of an extensive examination of mineral bodies, in which I was engaged in the years 1816 and 1817, for the purpose of investigating the laws of Polarisation and Double Refraction, I was led to the discovery of two general principles, which connected the optical condition of crystals with their mineralogical structure and their chemical composition. From the number of Axes of Double Refraction which any mineral possessed, I was enabled to determine the Class of Primitive Forms to which it belonged; and while every variation in the position, the intensity, and the character of these axes in similar minerals, was found to be accompanied with a difference of chemical composition, a difference of composition was also found to be accompanied with a difference of optical structure. All the combinations, too, of the sulphuric and tartaric acids, with a single earthy, alkaline and metallic base, were found to have *Two* axes of double refraction. The new paths which these determinations seemed to throw open to the philosophical mineralogist, promised to introduce an unexpected degree of precision into the science, and to decide many of those contested points which had been left unsettled, either from the imperfection of chemical analysis, or the indefinite indications of external characters. In the years 1816, 1817, and the beginning of 1818, I had opportunities of

explaining my views on these subjects to several foreign mineralogists, particularly to Major Petersen, Professor Gmelin of Tubingen, Professor Mohs of Freyberg, and Count Breunner, who took a deep interest in a subject so intimately connected with their own. The difficulty, however, of procuring analyses of the minerals and crystals which I had examined, prevented me from publishing in detail the results of my inquiry; but although the same difficulty still exists to a great degree, I have thought it necessary to lay before the public a notice of the principal results which I have obtained.

In August 1814, when I was in Paris, M. Biot presented to me a plate of *Arragonite*, from which he had determined that this mineral had one axis of double refraction, like Calcareous-spar *. Upon examining this plate, however, with care, I discovered that it had actually two axes of double refraction; and as all the other specimens which I subjected to examination had also two axes, a result which the primitive form of Arragonite rendered necessary, it appeared to me probable that the Carbonate of Strontian was not an essential ingredient in this mineral †; since those specimens in which it did not occur, had the same crystalline structure as those which contained it. I recommended it, however, to those who had the necessary specimens, to try if there was any difference in the optical structure of those Arragonites which did not contain the Carbonate of Strontian.

In the beginning of the year 1817, I received from Mr Henry Thomson of Cheltenham a quantity of crystals of the *Murio-sulphate of Magnesia and Iron*. They had the same crystallographic structure as Sulphate of Magnesia, but the inclination of the resultant axes was 51° 16′ in the Murio-sulphate, whereas it was only 37° 24′ in the Sulphate ‡. Some time after these experiments were made, this salt was analysed by Mr Richard Phillips ‖, who found it to consist of

* See *Traité de Physique*, tom. iv. p. 473, 478.

† The same conclusion was afterwards deduced, on other grounds, by Haüy.—See the *Journal of the Royal Institution*, vol. iv. p. 112., and the *Journal de Physique*, vol. lxxxv. p. 333. & 341, October and November 1817.

‡ See *Phil. Trans.* 1818, p. 30.

‖ *Annals of Philosophy*, Jan. 1818, vol. xi. p. 30.

Peroxide of Iron, - -	0.1 grain
Sulphate of Magnesia, -	61
Muriate of Magnesia, -	1.4
Water of Crystallisation, -	37.5
	100.0

Mr Phillips considers the Iron and the Muriate of Magnesia as merely accidental; but as I could not avoid doubting the accuracy either of the analysis or of this opinion, I transmitted several specimens of the salt to M. Berzelius. I am not yet able, however, to communicate his analysis.

In January 1817, I discovered the differences in the optical structure of the *Apophyllites* of Faroe and Uton *. These differences were so striking, as to entitle us to consider the two substances as distinct minerals. M. Berzelius has made a very accurate analysis of the apophyllite of Uton; but I have not yet received from him his analysis of the Faroe specimens. The composition of the Uton crystals is $KS^6 + 8CS^3$; and he conjectures that the Faroe ones may be composed of $KS^3 + 8CS^3$, or $KS^6 + 6CS^2$, with the same or a different dose of water.

A series of specimens which I received as *Acetate of Copper*, furnished me in the year 1817 with a still more striking proof of the connexion between the optical structure and the chemical composition of bodies. The green Acetate had two axes of double refraction, and also the faculty of absorbing polarised light; while the blue Acetate had only one axis, and was entirely destitute of the absorbent property †. In a large mass of crystals of acetate of copper which Dr Ure had the goodness to present to me in December 1817, the green and the blue acetate had been formed from the same solution, the blue crystals being on the outside of the mass. This circumstance seemed to render it highly probable that they were the same substance, notwithstanding the difference in their optical structure, and I accordingly requested Dr Ure to analyse them. The results of the analysis were as follows, the blue crystals being acetate of copper and lime, and the green crystals the bin-acetate of copper.

* See *Edin. Phil. Journal*, vol. i. p. 1.

† See *Phil. Trans.* 1818, p. 211.

Acetate of Copper and Lime.

	Experiment.		Theory.	
Acetic Acid, -	42.0	2 Atoms	13.0	41.87
Peroxide of Copper,	32.0	1 ——	10.0	32.20
Lime, - -	11.4	1 ——	3.55	11.43
Water, - -	14.6	4 ——	4.50	14.50
	100.0 *		31.05	100.00

Bin-acetate of Copper.

Acetic Acid, - - -	52.0
Peroxide of Copper, -	39.6
Water, - - - -	8.4
	100.0

M. Berzelius, to whom I sent specimens of the blue salt, also found it to consist of acetate of lime and deuto-acetate of copper, with water of crystallisation.

The crystals of *Nitrate of Strontian* present us with another example of optical analysis. I examined in 1816 some fine specimens of this substance, which Dr Hope had prepared from the native carbonate of strontian, and I found them to possess *Two* axes of double refraction. In 1817, I received from Mr William Allen of Plough Court some beautiful octohedral crystals of the same salt; but I was surprised to observe, that it had no double refraction at all †. This result obviously indicated a difference of chemical composition; and I therefore transmitted the crystals made by Dr Hope to M. Berzelius, who has favoured me with the following observations upon them. " This nitrate of strontian differs from the ordinary nitrate of strontian, both in its form, and in the circumstance that it contains a considerable quantity of water of crystallisation. On the supposition that it was a double salt, I gave it to M. Mitscherlich to analyse; but he did not succeed in finding a second base. If this salt should prove to be only a nitrate of strontian, with water of crystallisation, its production must depend on particu-

* We understand that Dr Ure observed some instructive peculiarities in analysing this salt, which we hope to lay before our readers in an early Number of this Journal.

† See *Phil. Trans.* 1818, p. 222. & p. 254.

lar circumstances, as we have not been able to produce a similar salt."

In examining several specimens of *Sulphate of Potash*, I found that those which were crystallised in the form of the the rhomboidal prism * and the bipyramidal dodecahedron †, had *two axes of double refraction*, while those which crystallised in hexaedral prisms had only one positive axis. M. Berzelius had the goodness to analyse for me these two different salts. The first he found to be the common sulphate of potash; but the second proved to be a double salt, composed of one atom of sulphate of potash and one atom of proto-sulphate of iron, with water of crystallisation.

The resemblance between *Talc* and *Mica* having induced several mineralogists to consider them as the same mineral, I began in 1816 to make a collection of different kinds of mica and talc, with the view of investigating their optical structure. The results of these experiments were sent to Sir Joseph Banks towards the end of 1817, and published in the Transactions for 1818. I found that talc was essentially different from the ordinary mica, the former having its resultant axes inclined at an angle of 7° 24′; while the inclination of the axes in one kind of *mica* was 45°. I found, also, that another species of mica had its resultant axes inclined 14°; and that *Lepidolite* had the same optical structure as the Siberian mica ‡. I sought in vain for that kind of mica which M. Biot had found to possess only *one axis* of double refraction; though I have since found the same property in mica from Kariæt in Greenland, and also in Mica containing Amianthus. The removal of one of the axes from these specimens of mica, was ascribed by M. Biot to *imperfect crystallisation*, which he supposed to produce an "*infinity of axes*" in the plane of the laminæ, arising from "the *crossing* of the axes of the integrant molecules ‖." I endeavoured in vain to understand how such an effect could be produced; but

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* See *Phil. Trans.* 1818, p. 211. 222.

† See this *Journal*, vol. I. p. 6. where it is shewn that the bipyramidal dodecahedron is in this case a compound form.

‡ *Phil. Trans.* 1818, p. 23.

‖ See *Mem. Institut.* 1812, p. 316. 334, 335. 346, 347. 351, 352.; and *Traité de Physique*, tom. iv. p. 543, 544. 553, 554.

when I found a specimen of mica that had the inclination of its resultant axes only 14°, or in which the axis in the plane of the laminæ was much feebler than in the Siberian mica, it became still more difficult to understand how irregular and confused crystallisation could have the power of weakening and removing one polarising axis, without affecting the other. The general law of polarisation and double refraction which I afterwards discovered, proved that such an explanation was inadmissible. From the external characters of the different Micas, I concluded that they were different substances, and I began to make a very large collection of them, for the purposes of analysis. M. Biot, however, seems afterwards to have abandoned this explanation, from having found several varieties of mica, in which the inclination of the resultant axes had different values *, and which, when analysed by M. Vauquelin, exhibited a difference in their chemical composition †.

Among some specimens of *Sulphate of Nickel* which I received from Mr Brande, and others for which I am indebted to Mr Badams of Birmingham, I found one set of crystals which had two axes of polarisation and double refraction, and in which the inclination of the resultant axes was 42°, and another set which had only one negative axis of double refraction. Nay, in one of these crystals, of a very uncommon size, the external portion had *one* axis of double refraction, while the central part of the crystal had *two*, the inclination of the resultant axes being about 3° ‡. The first set of these specimens, which I conceived to be pure sulphate of Nickel, from its having two axes, effloresced by exposure to the air; while the second set were in no way affected. I transmitted both to M. Berzelius, but I have not yet received his analysis of them. Since this paper was sent to press, Dr Fyfe ‖ has had the goodness to analyse the specimen with one axis, and he has found it to be a new triple salt, viz. a Sulphate of Nickel and Copper, composed as follows:

* Memoir read before the Institute, June 22. 1818.

† It appears strange that M. Vauquelin found no fluoric acid in any of these specimens of mica. See this *Journal*, vol. iv. p. 22.

‡ The results in this paragraph are given without any commentary in the tables printed in pages 211. and 230. of the *Phil. Trans.* for 1818.

‖ Dr Fyfe's analysis is published in a subsequent article of this Number, p. 210.

Water of Crystallisation, -	29.7
Sulphuric Acid, - - -	25.5
Oxide of Nickel, - -	39.5
Oxide of Copper, - - -	5.3
	100.0

a result which removes the only exception which I had found to the generality of the law respecting sulphates with a single base.

The *Nitrite of Lead*, formed by boiling the nitrate with metallic lead, crystallises in fine regular octohedrons of a yellowish colour, and is destitute of double refraction *. Mr Herschel afterwards examined this salt as made in a similar manner by himself; but he found that it crystallised in long, flat, yellow needles, and had two axes of double refraction. It must therefore have been a different substance from that which I used; and I suspect it to be the *Quadro-nitrite of Lead*.

The advantages of optical analysis will appear in a still more striking point of view, from a memoir on the Mesotypes which will soon be ready for publication. The examination of this interesting class of the Zeolites, was suggested to me in 1818, by Mr Warburton, to whom I had occasion to mention the results which I had obtained respecting the connexion between the optical structure and the chemical composition of minerals. This acute philosopher informed me, that Dr Wollaston had detected *Lime* in the Iceland Mesotype; whereas the Auvergne mineral contained *Soda* in place of lime; and he suggested this as an excellent test of the application of optical analysis. I lost no time in examining the structure of the mesotypes, with which I was amply supplied from the cabinets of Sir George Mackenzie, Mr Allan, and Mr Ferguson of Raith, which are always liberally open for the purposes of science, and I thus obtained results of which neither Mr Warburton nor myself could have had the most distant anticipation. The substance which Haüy calls *Mesotype*, includes no less than six separate mineral species, all of which are distinguished from one another by optical characters of the most marked and beautiful kind. Mineralogists speedily recognised a new mineral in the Mesotype epointée of Haüy.

* The crystals from which I obtained this result, were made for me by Mr Badams of Birmingham. See *Phil. Trans.* 1818, p. 254.

Dr Wollaston had discovered that the Iceland Mesotype differed from the mesotype of Auvergne, in the measure of its angles as well as in its chemical composition. Mr Brooke detected a new mineral species in the mesotype of Dunbartonshire; and I have found other two new minerals in the Nadelstein of Faroe and the Mesotype of Greenland. The optical structure of these *five* different species of mesotype I have examined with much attention, and have found them to differ from one another in the most remarkable manner.

EDINBURGH, *April* 20. 1821.

ART. II.—*Narrative of a Descent in the Diving-Bell, &c. &c.* By Dr LOUIS THEODORE FREDERICK COLLADON of Geneva, Hon. Mem. R. I. A. M. W. S. &c. * Communicated by the Author.

AMONGST the numerous applications of the sciences to the purposes of the arts, one of the most remarkable, and at the same time one of the most important, is undoubtedly that which has carried to so high a degree of perfection the Diving-Bell, and by this means rendered it one of the most useful of machines, not only in the practice of submarine architecture at great depths, but in mining or exploding the rocks which obstruct the entrance of harbours, or in obtaining from the bottom of the sea any valuable goods which may have been lost near the coast.

Having heard when I was in Ireland in September 1820 of the employment of this machine, which has been in use for several years past at Howth near Dublin, and of the sensations experienced by those who descend to the bottom of the sea, I was very desirous to ascertain in person the accuracy of the facts which had been stated to me. It was not long before an excellent opportunity presented itself. Having obtained from my friend Mr Bald a letter of introduction to Mr Souter, engineer at Howth Harbour, I left Dublin for Howth on the 8th of September 1820, with a friend, intending to go down in the diving-bell. The weather was very fine; the wind, however,

* Read before the Royal Society of Edinburgh, April 30. 1821.

rather high, and the sea rough. We got into a boat at eleven o'clock in the morning, and in a few minutes came alongside a vessel to which the diving-bell is attached. The workmen were then at the bottom of the water, employed in clearing the entrance of the harbour.

The bell in which we were to descend may be thus described. It was a kind of oblong iron chest, cast in one single piece, open below, 6 feet long, 4 broad, and 5 high: it weighed four tons; it was three inches thick at bottom, and half that thickness at top. It was cast in London, and, including the necessary apparatus and the air-pump, cost about £200. The bell being a great deal heavier than the water which it displaces, descends by its own weight. The upper part is pierced with eight or ten holes, in which are fixed the same number of convex glasses, very thick, which transmit the light. The glasses or lenses are fixed in the top of the bell, by means of a copper ring, screwed up against the glass, between which and the bell a coat of putty is laid, and then screwed hard up, so as to render it air-tight. The top is pierced with another hole, about an inch in diameter, which receives a long flexible leather pipe, intended to introduce into the bell the air compressed from above by a forcing-pump. In the inside of the bell is a valve which serves to close the aperture, and prevent the air from escaping.

In the interior, were two small benches on opposite sides of the bell, with a foot-board between them. There was room enough for four persons. From the middle of the roof descended several strong chains, intended to sustain a kind of iron-basket, in which they place the stones or other matters which they wish to carry up. The bell in which we went down was suspended by the centre with strong ropes, and managed by means of a moveable crane erected on the deck of a small vessel. We got into the bell, which was sufficiently elevated above the surface for that purpose, by means of a boat placed underneath it. We had with us two workmen.

We descended so slowly, that we did not notice the motion of the bell; but as soon as the bell was immersed in water, we felt about the ears and the forehead a sense of pressure, which continued increasing during some minutes. I did not, however, experience any pain in the ears; but my companion suffered so

much, that we were obliged to stop our descent for a short time. To remedy that inconvenience, the workmen instructed us, after having closed our nostrils and mouth, to endeavour to swallow, and to restrain our respiration, for some moments, in order that, by this exertion, the internal air might act on the Eustachian tube. My companion, however, having tried it, found himself very little relieved by this remedy. After some minutes, we resumed our descent. My friend suffered considerably: he was pale, his lips were totally discoloured; his appearance was that of a man on the point of fainting; he was in involuntary low spirits, owing, perhaps, to the violence of the pain, added to that kind of apprehension which our situation unavoidably inspired. This appeared to me the more remarkable, as my case was totally the reverse. I was in a state of excitement resembling the effect of some spirituous liquor. I suffered no pain; I experienced only a strong pressure round my head, as if an iron circle had been bound about it. I spoke with the workmen, and had some difficulty in hearing them. This difficulty of hearing rose to such a height, that during three or four minutes I could not hear them speak. I could not, indeed, hear myself speak, though I spoke as loudly as possible; nor did even the great noise caused by the violence of the current against the sides of the bell reach my ears. I thus saw confirmed by experience what Dr Wollaston had foreseen by theory in his curious and interesting paper on Sounds inaudible to certain ears *.

After some moments, we arrived at the bottom of the water, where every unpleasant sensation almost entirely left us. We were then twenty-seven feet below the surface. I confess that the recollection of the great depth, joined to the idea that if the smallest stone, or other matter, should obstruct the action of the valve, the bell would be instantly filled with water, did not fail to create for a short time a kind of uneasiness. One of the workmen, however, to whom I imparted my thoughts on that subject, desired me, with a smile, to look at one of the glasses placed above us, which I observed to be so much cracked in the middle, that bubbles of air were continually escaping.

* See this *Journal*, vol. iv. p. 160.

We breathed during the whole of our stay under water with much ease. We experienced now and then a great heat. Our perspiration was sometimes copious, and sometimes there suddenly came over us so thick a vapour as to prevent my seeing the workmen placed opposite me; but as by means of the signals they constantly sent us from above pure air, in so large quantities, that a great part of what was contained in the bell made its escape with great violence, this inconvenience very soon disappeared. Our pulse was not affected.

Mr Bald, who went down two days before me in one of the bells used at Howth, and to whose kindness I am indebted for the communication of his notes and observations, took with him a thermometer, and found the temperature of the air at the surface and in the inside of the bell to be 63° Fahr; while the temperature of the water within a foot of the bottom (that is to say nineteen feet below the surface) was 56° Fahr.

The light which we had in going down and at the bottom of the sea was very strong. Mr Bald could distinguish very easily in descending a great number of fishes, and other marine animals, which fled at the approach of the diving-bell. The sun shone bright, and I could write and read very easily. We gathered some fuci, (*Fucus filum*, *Fucus saccharinus*, &c.) We took some marine animals, and obtained several pieces of rock, which suggest some interesting views, explanatory of their formation, which is perhaps owing, as in the case of coral, &c. to certain animals. That part of the bottom of the sea which did not present any rock, was composed of sand and pebbles. The current of water was very violent; the colour of the water, as seen through the glasses, seemed to us to be of a light green: in the bell, where we had about ten or twelve inches of it, it was quite colourless.

Having remained more than an hour at the bottom, and having seen the men work as easily as in the open air, they made some signals, and we ascended, fully satisfied with what we had seen, and convinced of the facility and safety of these submarine operations. Before we went down, they had lost their basket at the bottom of the water, and, in order to find it again, they were obliged, in using their signals, to have the bell moved in every direction, which gave us the advantage of becoming well

acquainted with the method they employed to make themselves understood. In going up, the sensations which we experienced in the head were very different from those which we felt in descending. It seemed to us that our heads were growing larger, and that all the bones were about to separate. This disagreeable sensation, however, did not last long; we were in a short time above the surface, not only much pleased with what we had seen, but also with the idea of emerging safe from our narrow prison.

The signals made use of by the workmen are very simple: they consist in a smaller or greater number of strokes given with a hammer against the sides of the bell, according to the wishes of the workmen. These signals are easily heard on board, though no noise made above reaches the bell.

We must remark, that there is a north and south end fixed to each bell, and which is always attended to by those on board, so that they can be moved with accuracy whenever they want to work, either south, north, west or east.

The signals for the various operations are as follow:

1, Stroke means more air, or pump strong.
2, Stand fast, which is applicable to all motions.
3, Hoist.
4, Lower.
5, More south.
6, North.
7, Front.
8, Back.
9, Lower down the bucket.
10, Hoist up the bucket loaded, and so on.

The men also send up a note of what they want upon a label, which is instantly attended to if practicable, or some intimation sent down to them that it cannot be done. This is effected by means of a cord, one end of which is in the bell, and the other upon deck.

It is by the signals above described that the bell is moved from one place to another in search of stones. This is effected by raising the bell a few feet from the bottom, and then, by the aid of the moorings of the ship, the bell sweeps along in any desired direction. As soon as a large stone is discovered, a signal is made, the horizontal movement is stopped, and the bell lowered over the stone. If the bell be a little aside, the workmen can, by standing in the bottom of the sea, and pressing with their shoulders against the bell, make it swing a foot or two in

any direction, as it is suspended from an outrigger, at some height from the vessel's deck.

The men at Howth are principally occupied in clearing the entrance to the harbour. They are paid by the ton weight for what they quarry and send up, viz. 6s. 6d. *per* ton for very hard rock, that has chiefly to be blasted with gunpowder; 5s. 5d. *per* ton for easier quarried rock; and 4s. *per* ton for detached stone, gravel, and mud. At this rate, they are able to earn on an average 20s. *per* week all the year round. Their tonnage of rock averages 3¼ tons *per* day, and detached stone 5½ tons for four men.

The method of blowing up rocks by aid of the diving-bell, as practised in Ireland, is as follows. For an account of this process, I am entirely indebted to Mr Bald's kindness.

Three men are employed in the bell; one holds the jumper or boring-iron, the other two strike alternately quick, smart strokes with hammers. When the hole is bored of the requisite depth, a tin-cartridge, filled with gun-powder, about two inches diameter, and a foot in length, is inserted, and sand placed above it. To the top of the cartridge a tin-pipe is soldered, having a brass-screw at the upper end. The diving-bell is then raised up slowly, and additional tin-pipes with brass-screws are attached, till the pipes are about two feet above the surface of the water.

In the old practice, the tube was filled with powder as a train, and fired; but, in many instances, the heat melted the solder of the pipe, and the water entering extinguished the fire. The improved method is to leave the tube empty. The man who is to fire the charge is placed in a boat, close to the tube, and to the top of the tube a piece of cord is attached, which he holds in his left hand. Having in the boat a choffer with small bits of iron red-hot in it, he, with a pair of nippers, takes one of the bits of red-hot iron, and drops it down the tube, which instantly ignites the powder, and blows up the rock. A small part of the tube is destroyed next the cartridge; but the greater part, which is held by the cord, is reserved for future service. The workmen in the boat experience no shock by the explosion; the only effect is a violent eruptive ebullition of the water, arising from the explosion; but those who stand on the shore, and upon any part of the rocks connected with those which are blowing up, feel a very strong concussion, similar to

the shock of an earthquake. A certain depth of water is necessary for safety. Mr Bald supposes at least twelve feet.

The workmen cannot go down and work when the sea is very rough, as the swell would prevent them from settling on the bottom; and they are frequently annoyed with what is termed a *ground-swell*, when it is quite still at top. This is a sure prelude of a breeze of eastern wind, which seldom fails to set in soon after, if it has not prevailed at the time on the other side of the channel.

The best and easiest time for going down is at low water, when there is less pressure; but amateurs prefer going down at high-water, that they may have it to say that they were twenty or thirty feet below water in a diving-bell.

The workmen are generally down in the diving-bell five hours in the day, without coming up; and in summer, one set of men are down ten hours one day, and five hours the other; and so on alternately. They work at all seasons of the year, and do not feel much difference in the temperature. The water is more chilly in the winter; and when they come up into the atmospheric air, they feel it rather cold, after being heated by their exertions below. They do not complain in general of pains in the head, except those that are new hands, who are rather affected in that way, and about the ears; but this affection soon wears off.

They are in general rather relaxed in their bowels, which I suppose, is owing to their feet being constantly wet and cold. One of the men was very much affected with a bowel complaint this season, which increased as often as he went down. When Mr Souter descends, he is generally afflicted with a looseness: he has a copious flow of urine, and his appetite is very much increased. He always finds it a good plan to take a little spirits on coming up. The time never seems long to him when below; and he has been several times seven hours under water, without ascending, and scarcely thought it half that time.

None of the men become deaf, and it may be thought that in some cases it would be a cure for that malady.

They once had a man, as Mr Souter informed me, that was rather affected in his breathing, but when he commenced *belling*, it completely cured him.

The bellmen are in general very stout and healthy: their hard labour requires very good sustenance of three substantial meals in the day. Tea, bread, butter, eggs, bacon, potatoes, and fish, are their common diet. They are not particularly addicted to spirituous liquors. A little is very necessary for them, and it would require a good deal to affect them much.

I cannot conclude this paper, without repeating my best thanks to Mr Bald and Mr Souter, to whose kindness and liberality I am indebted for the greater part of the details introduced into this paper.

EDINBURGH, *April* 1821.

ART. III.—*Remarks on a Passage in the Mathematical Collections of Pappus, from which the Obliquity of the Ecliptic has been deduced.*

ERATOSTHENES, who was born 276 years before Christ, determined, by his own observations, that the obliquity of the ecliptic was 23° 51′ 19″.5. This quantity was adopted by Hipparchus, who lived about 100 years later, and even Ptolemy may be said to have used the same *. M. Delambre †, indeed, seems to think, that Ptolemy did not observe much himself; but, although he lived about 400 years later than Eratosthenes, even this interval would only have diminished the angle by a very few minutes, which probably was too small a quantity to have been ascertained by the instruments then in use. These records, however, of ancient astronomy, have always been considered as very important for ascertaining the variation of the angle, which the equator makes with the ecliptic; but there is another, which gives a result wholly irreconcileable with them. This is found in Pappus's Mathematical Collections, Book vi. Theor. 35., and the obliquity derived from the data there detailed, is no more than 23° 29′ 55″. Now, Pappus lived, according to Suidas, under the elder Theodosius, and consequently in the latter end of the fourth century from the Christian

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* *Histoire de l'Astronomie Ancienne*, vol. i. p. 87.

† *Ib.* Discours Preliminaire.

era; we may therefore roughly allow 6′ for the diminution of the angle in the interval from the time of Eratosthenes, and we shall then have 23° 45′ instead of a quantity, which is not widely different from the obliquity, as it was about 200 years ago. De la Hire rested much upon this passage, when he wished to shew that the angle was not liable to variation. "Il y a grande apparance," he says *, "que les astronomes d'Alexandrie, qui vinrent apres Ptolemee, s'appercurent bien que ses observations n'etoient pas fort justes, puisque Pappus, qui etoit aussi d'Alexandrie, et qui vivoit 270 ans apres Ptolemée, ayant ramassé tout ce qu'il y avoit de curieux dans les Mathematiques, dit, dans son 6me livre, où il rapporte 61 propositions sur la sphere, que l'obliquité de l'ecliptique etoit de 23° 30′, ce qui etoit sans doute fort connu pour lors." In answer to this, the Chevalier de Louville, who supported the opposite side of the question, acknowledged that the passage was against him, but he argued that it was a solitary authority: "Et † d'ailleurs il soutient que Pappus, dans l'endroit qu'on cite, n'a point pretendu donner une determination exacte, mais seulement tirer des racines quarrées, qui lui ont produit des nombres approchées." The latter part of this statement is not very clear: we shall find also that Pappus takes the squares instead of the square roots of his original numbers, and so far there is a mistake; but the former part contains the precise conclusion at which we must at last arrive.

Various hypotheses have been devised to reconcile this passage of Pappus with the authorities of Eratosthenes, Ptolemy, and of modern observations; but there would be no good obtained from a minute discussion of them. The same feeling, however, the same wish not to lose this additional authority, seems to influence even Lalande and Delambre; and their speculations call for more particular attention.

In the last edition of his astronomy, § 2741, Lalande admits, that the object which Pappus had in view was not to give an astronomical determination of the obliquity of the ecliptic; but still he evidently thinks it possible that some mistake may have occurred in the numbers. He says that we only

* *Mem. de l'Acad. Royale de Sciences*, 1716. † Ibid.

have them "en admettant l'interpretation de Commandinus, à laquelle Vendelinus n'a pas cru devoir deferer." M. Lalande does not in this place, with his usual precision, point out the work of Wendelinus, in which this opinion is to be found, and I have looked twice through the "*Loxias seu de obliquitate solis*, Antwerpiæ, 1626," without finding it. The passage from Pappus is discussed in pages 23, 24. of that work; but its incongruity with Ptolemy is there accounted for by a mistake in the latitude of Alexandria, where the observation is supposed to have been made, and by a neglect of allowing 7″ for the effect of parallax, when the sun was 7° 30′ from the zenith. It is not, however, worth while to spend time in tracing further, since the doubt derives its principal interest from the authority which is given to it by Lalande. It is well known that Commandine's book, to say the least, is most carelessly printed, so that if no error had been introduced either by the transcriber of the Greek text or by the translator, we can feel no certainty of the accuracy of the printer. The numbers, indeed, which occur in the commentary, agree so well with those in the text of Commandine, that, in the present instance, there can hardly be any press error in the expression of the fundamental ratios; but still there was evidently some general notion of possible mistake in the mind of Lalande, who certainly does not mention the suspicions of his author, as if he wholly rejected them.

Again, M. Delambre (*Astronomie Theorique et Pratique*, vol. iii. pages 181–2.), after stating the case at some length, and after distinctly laying down that Pappus had no intention of giving any precise determination of the obliquity, still seems to feel with others the wish to accommodate, if possible, the passage in question to what must have been the truth. He closes the seventh article of Chap. xxxii., by saying, "Lalande rejette sur le traducteur Commandin l'erreur de Pappus; mais, à moins de supposer une faute de copie ou d'impression, je ne vois pas ce qu'on peut objecter à l'interpretation et au commentaire de Commandin qui n'est qu'un calcul. Mais lisez 526 au lieu de 529, et vous aurez * $\omega = 23° 52'$, ce qui supposera

* ω is the symbol used by M. Delambre for the obliquity.

dans le Grec $\varphi\kappa\varsigma$ au lieu de $\varphi\kappa\theta$." If the original had been a work printed with Arabic numerals, I can easily conceive how an inversion of the type might have introduced a 6 for a 9; but I own that I can see no strong resemblance of the ς and the θ, which could have been likely to occasion the mistake in the transcriber of the Greek; neither do I see any other cause which could probably lead to it. Nevertheless such an error, if it did exist, might certainly remove some difficulty, and is therefore deserving of a more particular examination.

We are now come to a part of the inquiry, which does not admit of solution, without a reference to the original Greek, and this, as is well known, has never been printed: a few detached passages are inserted in various works; but the great body of what remains of the Συναγωγαι Μαθηματικη is only accessible to the generality of the readers in the Latin translation of Commandine. We have, however, some manuscripts in Great Britain, and I have been able to trace out four, which contain the passage under consideration: two of them are in the Savilian Library at Oxford; one is in the British Museum, and the fourth is in the Advocate's Library at Edinburgh. The three first I have myself carefully examined, and as Dr Brewster has taken the trouble of collating the fourth for me, I feel persuaded that the genuine text of the original is as follows:

" ....η της σφαιρας διαμετρος προς την του θερινου κυκλου διαμετρον λογον εχει δυναμει ον τα $\overline{\chi\kappa\theta}$ προς τα $\overline{\varphi\kappa\theta}$, επειπερ η απο του κεντρου της σφαιρας επι το κεντρον του τροπικου λογον εχει μηκει προς την εκ του κεντρου του τροπικου ον τα $\overline{\iota}$ προς τα $\overline{\kappa\gamma}$, ελασσων αρα η διπλασια εστιν η της σφαιρας διαμετρος της του τρόπικου διαμετρου.

I now subjoin the translation, and as reference has been made to the commentary, I have annexed the only two remarks which Commandine has made upon the passage.

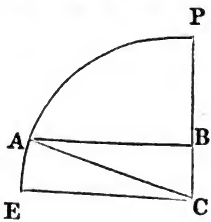
" ....quoniam sphæræ diameter ad diametrum æstivi tropici potestate eandem habet proportionem, quam 629 ad 529, etenim recta linea a centro sphæræ ad centrum tropici ducta, longitudine eam proportionem habet ad semidiametrum tropici, quam 10 ad 23 (¹), erit sphæræ diameter minor quam dupla (²) diametri tropici."

(¹) " Sinus enim rectus maximæ declinationis solis, videlicet $23\frac{1}{2}$ est 23924 earum partium quarum semidiameter sphæræ est 60000, et sinus rectus residui maximæ declinatio-

nis, hoc est semidiameter tropici est 55023, habet autem 23924 ad 55023 eandem fere proportionem quam 10 ad 23."

(²) "Habet enim sphæræ diameter ad diametrum tropici eam fere proportionem quam $25\frac{2}{25}$ ad 23."

The general fidelity of the translation will be evident from a comparison of the Latin with the Greek, and their agreement is most favourable to the text as it now stands. It is worthy of observation, likewise, that, with respect to the numerals, there is no difference whatever in the manuscripts, excepting that some of them have εικοσι τρια in the place of κ̄γ, which only confirms the accuracy, in this instance, of the present reading. But it may be said, that one transcriber often copies the errors of another, and that these may be detected by the internal evidence from the context. This is very true, but it is wholly inapplicable to the support of the proposed correction. On the contrary, the internal evidence is, I conceive, conclusive against any alteration. M. Delambre says very justly, "Pappus dit que le diametre de la sphere est en puissance à celui du tropique comme 629 : 529, d'ou je tire cos. $\omega = \left(\frac{529}{629}\right)^{\frac{1}{2}} = 23° 29' 50''$*;" but he omits all allusion to the latter part of the passage, and this, I think, if he had attended to it, would have prevented him from suggesting the conjectural emendation. It will be observed that 629, 529 are not the original numbers, on which the reasoning is founded. They are derived from the other ratio of 10 to 23: this is clearly pointed out by the use of the conjunction επειπερ. Now, this being admitted, which can hardly be disputed, it follows that the larger numbers could be none other than as they now stand. For, let C be the centre of the sphere, CP its axis, CE the radius of the equator, AB the radius of the tropic; join AC, and then, by the conditions of the



* It is hardly worth mentioning, but the quantity strictly is greater by 5″.

Log. 529	2.7234557
Log. 629	2.7986507
	2)9.9248050
	9.9624025 which is the Cosine of 23° 29′ 55″.

proposition, $BC : AB :: 10 : 23$

$BC^2 : AB^2 :: 100 : 529$

$BC^2 + AB^2 : AB^2 :: 100 + 529 : 529$, that is, since ABC is a a right angle, $AC^2 : AB^2 :: 629 : 529$.

Now, the square root of 629 is 25.08. or $25\frac{2}{25}$, as Commandine writes it, which not being a whole number, the proportion is left in the expression of the squares. All this is very clear and plain; but, if we invert the order of reasoning, and suppose 629, 526 to be the original numbers, we shall have

$$AC^2 - AB^2 : AB^2 :: 629 - 526 : 526, \text{ that is,}$$
$$BC^2 : AB^2 :: 103 : 526, \text{ and}$$
$$BC : AB :: \sqrt{103} : \sqrt{526}.$$

Now, there appears no reason why our author should, in the first instance, have assumed quantities, of which he was afterwards to take the square roots; and it is not likely, if he had done so, that he would have fixed on such as these, of which the roots are not to be found in whole numbers. Besides, the diameters of the circles were all that he had occasion for; and if he had them, there was no need of the ratio of BC to AB. All this is the more evident from the wide range which his object afforded him. The conclusion which he draws from his premisses is, that the diameter of the sphere is less than double the diameter of the tropic; and this would be true for an obliquity of any magnitude which was less than 60°; consequently it was of no importance whether he made it a few minutes, or even a few degrees too little or too great.

The ratio of 10 to 23 gives an obliquity so very near to 23° 20′, that it seems to be derived from that quantity. Indeed, Commandine, in his first note, has proceeded on this idea. 23° 30′, likewise, forms a kind of round number, which, as Johnson somewhere remarks, will almost always be inaccurate, and therefore might have given rise to suspicion: but I can see no other reason why it should have been fixed on; and I am inclined to believe that it is an accidental consequence of the ratio which was adopted. Pappus, in all probability, as M. Lalande remarks, "n'etoit pas autant observateur qu' Erastothene, Hipparque et Ptolemée;" it may, therefore, be fairly supposed that he took his original quantity from Ptolemy, and he was the more

likely to do so, as there was no suspicion in his time of any variation. If this were so, he would have had BC : AB : : sin. ω : cosin ω : : 1 : $\frac{\text{cosin } \omega}{\text{sin } \omega}$: : 1 : cotan ω, and 1 : cot 23° 51′ 20″ : : 10 : 22.6. Now, this is so nearly the ratio of 10 to 23, that he might have adopted the whole numbers for his purpose, without any thought of indicating a difference in the obliquity from that which had been used by Ptolemy.

Upon the whole, then, I think we may fairly conclude that no alteration is required, and that none can be admitted in the original text. And this supposition having been disposed of, nothing can be mose just than the following description of the passage, which M. Delambre himself gives in the other part of his remarks: "Pappus n'a nullement en vue de nous donner une determination bien juste de l'obliquité; pour prouver une proposition sur la vitesse du mouvement du soleil, il n'a besoin que d'un aperçu bien grossier de la grandeur du tropique. C'est ainsi qu' Archimede, dans son Arenaire, pour etablir son calcul, suppose au rayon de la sphere des fixes une grandeur qu'il n'a pas pretendu donner comme exacte à beaucoup pres. Le temoignage de Pappus n'a donc pas ici plus de poids que n'en aurait celui d' Archimede dans la question de la parallaxe des etoiles."

R.

OXFORD,
April 1821.

ART. IV.—*Account of the Atush Kudda, or Natural Fire Temples of the Guebres, formed by burning Springs of Naphtha, with a Notice respecting the Naphtha Wells in Pegu* *.

THE ancient sect of the Guebres or Parsees, distinguished from all others as the worshippers of Fire, derived their opi-

* This article has been drawn up from information contained in the Travels of Forster, Hanway, Rieberstein, Cook, Kinneir, and Hiram Cox, and from a paper written by M. J. J. Virey, and published in the *Journal de Pharmacie* for May 1820, vol. vi. p. 209.—D. B.

nions from Zoroaster. They had their origin in Persia, but, in consequence of different persecutions with which they were assailed, many of them quitted the kingdom, and, after various migrations, they found an asylum in Surat, Bombay, and other settlements on the Malabar Coast.

Those who remained in Persia experienced even a harder fate than their migratory brethren, and, by the oppressions and exactions of the government, have been reduced to a state of the most abject degradation.

The Persian Guebres inhabit principally the shores of the Caspian Sea, and the cities of Ispahan, Yezd* and Kerman. Their great Fire Temple, however, called *Attush Kudda*, *Atashghah*, or *Atechgah*, is in the neighbourhood of Badku, which, before the conquest of the Saracens, was annually visited by thousands of pilgrims.

The town of Badku, which is one of the largest and most commodious ports on the Caspian Sea, stands in the Peninsula of Abscharon, in Lat. 42° 22′ North. The earth in the neighbourhood of this city is completely impregnated with naphtha. The inhabitants of Badku have no other fuel, and no other light but that which they derived from this substance. The black petroleum, when formed into small cakes or balls, with a mixture of sand, is used as fuel. Three of these balls is sufficient for heating an oven for baking bread, but the bread in this case contracts a very disagreeable odour as well as taste. It supplies also the lamps, and forms the fires of the lower classes, and it is used as a covering for the flat roofs of their houses, which it effectually protects from rain.

About ten miles to the north-east of the town, are still seen the ruins of the ancient temples which the Guebres had erected. The religious retirement, according to Forster, where the devotees worship the deity in the resemblance of Fire, is a square of about 30 yards, surrounded with a low wall, and containing many apartments. In each of these is a small volcano of sulphureous fire issuing from the ground, through a furnace or funnel, in the form of a Hindoo altar. This fire is appropriated to the purposes of cookery as well as of worship, and for

* There are no fewer than 4000 Guebres in the town of Yezd.

fortifying the Hindoos against the rigours of the cold season. On closing the funnel the flame is immediately extinguished, and a hollow sound is heard, (by applying the ear to the aperture,) accompanied with a strong and cold current of air, which may be fired at pleasure, by placing near it any flaming substance. The flame is of a pale clear colour, without any sensible smoke, and emits a vapour strongly impregnated with sulphur, which impedes respiration, unless when the head is brought lower than the level of the furnace. The Guebres have a wan and emaciated appearance, and are oppressed with a hectic cough, which also affected Mr Forster during his visit. The ground within the inclosure abounds with this subterraneous fire, which issues from artificial channels; but it requires always to be lighted by another flame.

Besides these fires in the apartments of the Guebres, a large one, springing from a natural cliff, in an open place, continually burns. Many of these volcanoes are seen on the outside of the wall, and have the appearance of limekilns. The general space which contains this volcanic fire, is something less than a mile in circumference. It forms a low flat hill slanting towards the sea, the soil of which consists of a sandy earth intermixed with stones. Mr Forster observes, that no mountainous land is seen from the Atush-Kudda, nor any violent eruption of flame; but Mr Kinneir informs us *, that "the whole country round Badku has at times the appearance of being enveloped in flames. It often seems," he adds, "as if the fire rolled down from the mountains in large masses, with incredible velocity; and during the clear moonshine nights of November and December, a bright blue light is observed at times to cover the whole western range. This fire does not consume, and if a person finds himself in the middle of it, no warmth is felt."

The whole ground, for about two miles in circuit around the principal fire, has the remarkable property of being enflamed by a burning coal, when it is scraped only to the depth of two or three inches; but in this case it does not communicate fire to the neighbouring ground. If the earth, however, is dug up with a spade, and a torch brought near it, an exten-

* *Geographical Memoir of the Persian Empire*, p. 360.

sive, but instantaneous deflagration takes place; and from this cause houses have frequently been burned, and even men exposed to danger.

If a hollow cane, or merely a tube of paper, is sunk about two inches into the ground, and if we blow upon a burning coal brought near its upper orifice, there will issue a slight flame, which will neither burn the cane nor the paper. This method is employed by the inhabitants for illuminating houses that are not paved; and by means of these hollow canes from which the fire issues, they boil the water in their coffee-urns, and even cook different articles of food. In order to put out the flame, it is necessary only to plug up the orifice. The most rocky parts of the ground furnish the most active and brilliant flame. The smell of naphtha is diffused, but, after being accustomed to it, it ceases to be disagreeable.

The inhabitants employ this natural fire even in calcining lime. The stones are placed one above another, in a place opened to receive them, and in less than three days they are generally perfectly calcined. Sulphur is dug up near the same spot where the springs of naphtha are found.

The small Island of Wetoy is the principal place where the black petroleum and naphtha of an amber colour are obtained; but it is substituted only when the workmen go to procure these substances. The Persians carry away great quantities in their vessels, but they are generally in such a bad condition, that the naphtha finds its way into the sea, which is often covered with it to the distance of several leagues. In gloomy weather, or when the heavens are covered with stormy clouds, the springs are in a state of greatest ebullition, and the naphtha, which often takes fire spontaneously at the surface of the earth, flows burning to the sea, in quantities, and to a distance which is quite inconceivable. When the sky is clear, and the weather serene, the ebullition of the springs does not exceed two or three feet.

In consequence of boiling, the petroleum acquires, by the evaporation of the more volatile naphtha, a degree of consistence that obstructs by degrees the orifice of the spring, which then becomes surrounded with small heaps of maltha or earthy mineral pitch, a black substance, as hard and tenacious as pitch. When the resistance of this accumulation overcomes the force of

the spring, the naphtha finds some other opening. Springs which have not been long opened, have an embouchure from 8 to 10 feet in diameter.

The naphtha flows from these springs into reservoirs by means of small cuts, and when one reservoir is full, another cut conducts it into another reservoir. In the first reservoir are left the water and the grosser parts which accompany the naphtha from the spring. This coarser matter, which has a strong and penetrating odour, is used for fuel only by the poorest classes of the Persians and other neighbouring nations. It is principally employed as a substitute for oil, or for making the fire-balls already mentioned. It is necessary, however, to preserve it in close vessels, as conflagrations often happen from its susceptibility of taking fire by the approach of a flame.

The whitest and the purest naphtha is obtained principally from the Peninsula of Apcheron. It is more fluid and more volatile than any other kind, but it is obtained only in small quantities. The Russians drink it as a cordial, but it never intoxicates them. When taken internally, it is thought to be useful in cases of the stone, in pains in the head and chest, and in venereal affections and *blennorrhagia,* maladies to which the Persians and Russians are very much subject. The latter are said to drink the volatile oil of turpentine in the same manner, and in as great quantities.

Naphtha is also used externally for scorbutic spots, and in cases of gout, bruises, sprains of the tendons, and nervous spasms. Care, however, is taken to apply it only on the places affected, as, from its extreme subtlety, it is easily absorbed by the lymphatics, and, by impregnating the system, it may occasion the severest pains. It is necessary also to keep off any ignited body, lest the person rubbed with naphtha should take fire.

Naphtha is also employed in the same manner as alcohol, for removing spots of grease from woollen and other stuffs, but it is difficult to destroy the disagreeable smell which it occasions. It is also said to form a very brilliant and durable varnish, by dissolving in it resinous bodies.

Near the naphtha springs are springs of warm water, which boils like that which flows along with the naphtha. Baths are formed with these waters, after they are clarified from the blu-

ish clay which they suspend, and they are said to be of a strengthening nature, and to excite the appetite of those who use them, and at the same time drink the waters. From these causes, persons of distinction, and invalids, are attracted from distant countries to make use of the springs.

To the east of the Peninsula of Apcheron, there are several islands which produce also naphtha of different degrees of purity. The Russians call them *Svetoi otrophi*, or the Holy Isles. According to Mr Kinneir, the quantity of naphtha procured in the plain to the south-east of Badku is enormous. It is drawn from wells, some of which yield from 1000 to 1500 lb. a-day. The wells are in a certain degree inexhaustible, since they begin to fill as soon as they are emptied, and the naphtha increases till it attains its former level.

In the middle of the Pass, between the district of Kerkook, in the Pachalick of Bagdad, and the fine plain of Altun Kupri, are a number of naphtha pits, which yield an inexhaustible supply of it. Many of the pits are in the bed of a small stream, which forces a passage through the rocks. They are about 3 feet in diameter, and some of them from 8 to 10 feet deep. It is here in a liquid state, and perfectly black, and is conveyed from the bottom to the top in leathern buckets, and is then sent over the country in earthen jars.

Mr Kinneir considers the white naphtha as a substance entirely different from the black kind, resembling tallow more than any thing else. It floats like a crust on the surface of the water, while the black is procured by digging a small pit in the ground. The only fountain of white naphtha which Mr Kinneir saw was at the foot of the mountains of Bactiari, half way between the city of Shuster and the valley of Ram Hormouz.

We shall now conclude this article with an account of the Naphtha Wells at Rangoon, in the Kingdom of Pegu, the particulars of which are taken from the account given by Captain Hiram Cox, formerly resident at that place.

At Rangoon there are 180 wells; and about four or five miles to the N. E. there are no fewer than 340 more. Before sinking a well, the hill is cut down into a square table of 14 or 20 feet, and from that table a road is formed by scraping away an

inclined plane upon the excavated earth, by which the oil may be removed. The inside of the well, which is of a square shape, is lined as it proceeds, with squares of cassia wood staves, each of which is about 6 feet long, 6 inches broad, and 2 inches thick. They are rudely jointed together, and pinned at right angles to each other, so as to form a square frame about 4½ feet for the uppermost ones, but more contracted below. The wells belong to the proprietors of the ground, some families possessing four or five, and are sunk and wrought for their benefit. The expence of sinking a new well is about 2000 ticals of flowered silver, or about 2500 sicca rupees, and the average profit annually is about 1000 ticals. The oil is always drawn pure from the wells, the temperature preserving it in a liquid state when in the well. In cold weather, however, it congeals in the open air. It is of a dingy green colour and odorous. It is used in lamps, and when boiled with a little dammer, it is used for painting the timbers of houses, and the bottoms of boats, which it protects against the attacks of vermin. It is used also as a lotion in cutaneous eruptions, and as an embrocation in bruises and rheumatic affections.

Each well yields at an average about 500 vis, or 1825 lb. avoirdupois *per* day, and the labourers earn above 8 ticals *per* month. Each well is worked by four men, who receive one-sixth of the value of the oil obtained, either in money or in oil, at the option of the proprietor. Mr Cox calculates the gross amount of oil obtained every year from the 520 wells registered by government, to be 92,781 tons, or 412,360 hhds. the value of which at the well will be (at the rate of 1¼ tical for 100 vis,) 711,750 ticals, or 289,737 sicca rupees.

The oil is carried from the wells in small jars by coolies, or in carts, to the river, where it is delivered to the merchant exporter, at 2 ticals *per* 100 vis. The gross value, therefore, or profit to the country, deducting 5 *per cent.* for wastage, may be stated at 1,081,860 ticals, or 1,362,325 sicca rupees *per annum*, or about L. 170,290 Sterling, yielding a direct annual revenue to the King of 166,232 sicca rupees, or L. 17,029 Sterling. About 70 or 80 boats, of the average burden of 60 tons, are constantly loading oil at the wharf, besides others going and coming. A number of boats and men are also constantly employed in providing pots, &c. for the oil.

Art. V.—*On Isothermal Lines, and the Distribution of Heat over the Globe.* By Baron Alexander de Humboldt. (Concluded from Vol. IV. p. 281.)

I SHALL now conclude this Memoir by the enumeration of the most important results which have been obtained by Baron Von Buch, M. Wahlenberg, and myself, on the distribution of heat in the interior of the earth, from the Equator to 70° of N. Lat., and from the plains to 3600 metres (11,808 feet) of elevation. I shall limit myself to an enumeration of the facts. The theory by which these facts are connected, will be found in the fine analytical work with which M. Fourier will soon enrich natural philosophy.

The interior temperature of the earth is measured either by the temperature of subterraneous excavations, or by that of springs. This kind of observation is very liable to error, if the traveller does not pay the most minute attention to local circumstances, which are capable of altering the results *. The air, when cooled, accumulates in caverns, which communicate with the atmosphere by perpendicular openings. The humidity of rocks depresses the temperature by the effect of evaporation. Caverns that have little depth are more or less warmed, according to the colour, the density, and the moisture, of the strata of stone in which nature has hollowed them. Springs indicate too low a temperature, if they descend rapidly from a considerable height upon inclined strata. There are some under the torrid zone and in our climate, which do not vary in their temperature throughout the whole year more than half a degree; and there are others which shew the mean temperature of the earth only by observing them every month, and taking the mean of all the observations. From the Polar circle to the Equator, and from the tops of mountains towards the plains, the progressive increase of the temperature of springs diminishes with the

* Baron von Buch, in the *Bibl. Brit.* tom. xix. p. 263.; Saussure, *Voyages*, sect. 1418.; Wahlenberg, *De Veget. Helvet.* Pl. 77.—84.; Gilbert, *Annalen*, 1812, p. 150. 160. 277.; Lambert, *Pyrometrie*, p. 296. Dr Roebuck appears to have been the first who entertained exact notions on the temperature of springs, and upon their relation to the mean temperature of the air; Phil. Trans. 1775, vol. lxv. p. 461.

mean temperature of the ambient air. The temperature of the interior of the earth is, at

	Lat.	Temp. Fahr.		Lat.	Temp. Fahr.
Vadso,	70°.0	35°.96	Paris,	48° 50′	53.°6
Berlin,	52.31	49.28	Cairo,	30 2	72.5

In equinoctial America, I have found it in the plains from 77° to 78°.8.

The following are examples of the decrease of temperature from the plains to the tops of mountains.

	Alt. in Feet.	Temp. Fahr.
Spring of Utliberg, near Zurich, -	1532	48°.92
Ditto of Rossbaden at St Gothard, -	7016	38.30

Between the Tropics I have found,

	Alt. in Feet.	Temp. Fahr.
Springs of Cumanacoa, - -	1,148	72°.5
Ditto Montserrate, above Santa Fé de Bogota,	10,680	59.9
Ditto in the Mine of Hualgayoc in Perú,	11,759	53.24

In the plains, and to the height of 3280 feet, between the parallels of from 40° to 45°, the mean temperature of the earth is nearly equal to that of the ambient air; but very accurate observations by Baron Von Buch and Wahlenberg tend to prove, that in high latitudes, towards the top of the Swiss Alps, for example, beyond the height of 1400 or 1500 metres (4592 or 4920 feet), the springs and the earth are 5°.4 warmer than the air.

Zone of 30°—55°.	Lat.	Mean Temp. of Air, Fahr.	Temp. of the Interior of the Earth.
Cairo, - -	30° 2′	72°.68	72°.50
Natchez, - -	31 28	64.76	64.94
Charlestown, - -	33 0	63.14	63.50
Philadelphia, - -	39 56	53.42	52.16
Geneva, - - -	46 12	49.28	50.74
Dublin, - - -	53 21	49.10	49.28
Berlin, - - -	52 31	47.30	49.28
Kendal, - -	54 17	46.22	47.84
Keswick, - -	54 33	48.02	48.56
Zone of 55°—70°.			
Carlscrona, - -	56 6	46.04	47.30
Upsal, - -	59 51	41.90	43.70
Umeo, - -	63 50	33.26	37.22
Vadso, - -	70 0	29.66	35.96

At Enontekies, in 68½° of Lat. the difference between the mean temperatures of the earth and the air, is so great as 7°.74. Analogous differences are observed on the back of the Alps, at the altitude of 1400 metres (4592 feet).

In the following small table, I have added the mean temperature of the atmosphere, by supposing, with M. Ramond, that there is a decrease of 1° centigrade for 164 metres (1° Fahr. for 300 feet nearly), and by placing the temperature of 32° (according to observations made at the Hospice of St Gothard), at 1950 metres (6396 feet) of elevation.

	Alt. in Feet.	Temperature. Springs.	Air.
Rigi Kaltebad, -	4717	43°.7	38°.12
Pilate, - -	4858	41.0	37.40
Blancke Alp, -	5786	37.4	35.78
Rossbaden, - -	7016	38.3	31.38

It may be objected, that in the Alps of Switzerland, the temperature of springs has only been observed from the beginning of June to the end of September, and that the differences between the air and the interior of the earth would almost entirely disappear, if we knew the temperature of the springs during the whole year. It must not be forgotten, however, that the springs of the Alps did not vary in the space of *four* months at the time of the observations of M. Wahlenberg;—that among the small number of scanty springs which indicate changes of temperature in different seasons, these variations amount from June to September to 11° or 15°;—and that several springs, particularly those which are very copious, do not vary during a whole year more than half a degree of Fahrenheit.

It appears to me, therefore, sufficiently certain, that where the earth is covered with a thick stratum of snow, while the temperature of the air descends to 15° or —4° of Fahrenheit, the temperature of the earth is above the mean temperature of the air.

When we consider what a large portion of the globe is covered with the sea, and examine the temperature of the deepest waters *, we are constrained to admit, that in islands, along

* At Funchal in Madeira, the temperature of caverns appears to be 61°.16, and consequently 7°.2 *below* that of the air.—*Phil. Trans.* 1778, p. 372.

coasts, and perhaps even in continents of small extent, the interior heat of the earth is modified by the proximity of the strata of rocks on which the waters of the ocean rest.

I have considered successively in this memoir, the distribution of heat,

1. At the surface of the globe.
2. On the declivity of mountains.
3. In the ocean.
4. In the interior of the earth.

In explaining the theory of isothermal lines and their inflexions, which determine the different systems of climates, I have endeavoured to reduce the phenomena of temperature to empirical laws. These laws will appear much more simple, when we shall have multiplied and rectified by degrees the numerical elements which are the results of observation.

In the following general Table of the distribution of heat, the temperatures are expressed in degrees of Fahrenheit; the longitudes are reckoned from east to west of the meridian of the observatory of Greenwich. The mean temperatures of the seasons have been calculated, so that those of the months of *December*, *January*, and *February*, form the mean temperature of *Winter*. An asterisk (*) is prefixed to those places whose mean temperatures have been most accurately determined, and in general by means of 8000 observations. The isothermal lines have a convex summit in Europe, and two concave summits in Asia and Eastern America

Isothermal Bands.	Names of Places.	Position. Lat.	Long.	Height in Feet.	Mean Temp. of the Year.	Distribution of Heat in the different Seasons. Mean Temp. of Winter.	Mean Temp. of Spring.	Mean Temp. of Summer.	Mean Temp. of Autumn.	*Maximum* and *Minimum*. Mean Temp. of Warmest Month.	Mean Temp. of Coldest Month.	
Isothermal Bands from 32° to 41°.	Nain,	57° 8′	61° 20′ W	0	26°.42	—0°.60	23°.90	48°.38	33°.44	51°.80	—11°.20	1
	* Enontekies,	68 30	20 47 E	1356	26.96	+ 0.68	24.98	54.86	27.32	59.54	— 0.58	2
	Hospice de St Gothard,	46 30	8 23 E	6390	30.38	18.32	26.42	44.96	31.82	46.22	15.08	3
	North Cape,	71 0	25 50 E	0	32.0	23.72	29.66	43.34	32.09	46.58	22.10	4
	* Uleo,	65 3	25 26 E	0	35.08	11.84	27.14	57.74	35.96	61.52	7.70	5
	* Umeo,	63 50	20 16 E	0	33.26	12.92	33.80	54.86	33.44	62.60	11.48	6
	* St Petersburg,	59 56	30 19 E	0	38.84	17.06	38.12	62.06	38.66	65.66	8.60	7
	Drontheim,	63 24	10 22 E	0	39.92	23.72	35.24	61.24	40.10	64.94	19.58	8
	Moscow,	55 45	37 32 E	970	40.10	10.78	44.06	67.10	38.30	70.52	6.08	9
	Abo,	60 27	22 18 E	0	40.28	20.84	38.30	61.88	40.64	—	—	10
Isothermal Bands from 41° to 50°.	* Upsal,	59 51	17 38 E	0	42.08	24.98	39.38	60.26	42.80	62.42	22.46	11
	* Stockholm,	59 20	18 3 E	0	42.26	25.52	38.30	61.88	43.16	64.04	22.82	12
	Quebec,	46 47	71 10 W	0	41.74	14.18	38.84	68.00	46.04	73.40	13.81	13
	Christiania,	59 55	10 48 E	0	42.8	28.78	39.02	62.60	41.18	66.74	28.41	14
	* Convent of Peyssenburg,	47 47	10 34 E	3066	42.98	28.58	42.08	58.46	42.98	59.36	30.20	15
	* Copenhagen,	55 41	12 35 E	0	45.68	30.74	41.18	62.60	48.38	65.66	27.14	16
	* Kendal,	54 17	2 46 W	0	46.22	30.86	43.14	56.84	46.22	58.10	34.88	17
	Malouin Islands,	51 25	59 59 W	0	46.94	39.56	46.58	53.06	48.46	55.76	37.40	18
	* Prague,	50 5	14 24 E	0	49.46	31.46	47.66	68.90	50.18	—	—	19
	Gottingen,	51 32	9 53 E	456	46.94	30.38	44.24	64.76	48.74	66.38	29.66	20
	* Zurich,	47 22	8 32 E	1350	47.84	29.66	48.20	64.04	48.92	65.66	26.78	21
	* Edinburgh,	55 57	3 10 W	0	47.84	38.66	46.40	58.28	48.56	59.36	38.30	22
	Warsaw,	52 14	21 2 E	0	48.56	28.76	47.48	69.08	49.46	70.34	27.14	23
	* Coire,	46 50	9 30 E	1876	48.92	32.36	50.00	63.32	50.36	64.58	29.48	24
	Dublin,	53 21	6 19 W	0*	49.10	39.20	47.30	59.54	50.00	61.16	35.42	25
	Berne,	46 5	7 26 E	1650	49.28	32.00	48.92	66.56	49.82	67.28	30.56	26
	* Geneva,	46 12	6 8 E	1080	49.28	34.70	47.66	64.94	50.00	66.56	34.16	27
	* Manheim,	49 29	8 28 E	432	50.18	33.80	49.64	67.10	49.82	68.72	33.44	28
	Vienna,	48 12	16 22 E	420	50.54	32.72	51.26	69.26	50.54	70.52	26.60	29

Isothermal Bands from 50° to 59°.	* Clermont, -	45 46	3 5 E	1260	50.00	34.52	50.54	64.40	51.26	66.20	28.04	30
	* Buda, -	47 29	19 1 E	494	51.08	33.98	51.08	70.52	52.34	71.60	27.78	31
	Cambridge, (U.S.)	42 25	71 3 W	0	50.36	33.98	47.66	70.70	49.82	72.86	29.84	32
	* Paris, -	48 50	2 20 E	222	51.08	38.66	49.28	64.58	51.44	65.30	36.14	33
	* London, -	51 30	0 5 W	0	50.36	39.56	48.56	63.14	50.18	64.40	37.76	34
	Dunkirk, -	51 2	2 22 E	0	50.54	38.48	48.56	64.04	50.90	64.76	37.75	35
	Amsterdam,	52 22	4 50 E	0	51.62	36.86	51.62	65.84	51.62	66.92	35.42	36
	Brussels, -	50 50	4 22 E	0	51.80	36.68	53.24	66.20	51.08	67.28	35.60	37
	* Franeker, -	52 36	6 22 E	0	51.80	36.68	51.08	67.28	54.32	69.08	32.90	38
	Philadelphia,	39 56	75 16 W	0	53.42	32.18	51.44	73.94	56.48	77.00	32.72	39
	New York,	40 40	73 58 W	0	53.78	29.84	51.26	79.16	54.50	80.78	25.34	40
	* Cincinnati, -	39 6	82 40 W	510	53.78	32.90	54.14	72.86	54.86	74.30	30.20	41
	St Malo, -	48 39	2 1 W	0	54.14	42.26	52.16	66.02	55.76	66.92	41.74	42
	Nantes, -	47 13	1 32 W	0	54.68	40.46	54.50	68.54	55.58	70.52	39.02	43
	Pekin, -	39 54	116 27 E	0	54.86	26.42	56.30	82.58	54.32	84.38	24.62	44
	* Milan, -	45 28	9 11 E	390	55.76	36.32	56.12	73.04	56.84	74.66	36.14	45
	Bourdeaux, -	44 50	0 34 W	0	56.48	42.08	56.48	70.88	56.30	73.04	41.00	46
Isothermal Band from 59° to 63°.	Marseilles, -	43 17	5 22 E	0	59.00	45.50	57.56	72.50	60.08	74.66	44.42	47
	Montpellier,	43 36	3 52 E	0	59.36	44.06	56.66	75.74	60.98	78.08	42.08	48
	* Rome, -	41 53	12 27 E	0	60.44	45.86	57.74	75.20	62.78	77.00	42.26	49
	Toulon, -	43 7	5 50 E	0	62.06	48.38	60.80	75.02	64.40	77.00	46.40	50
	Nangasacki,	32 45	129 55 E	0	60.80	39.38	57.56	82.94	64.22	86.90	37.40	51
	* Natchez, -	31 28	90 30 W	180	64.76	48.56	65.48	79.16	66.02	79.70	46.94	52
Isothermal Band from 68° to 77°.	* Funchal, -	32 37	16 56 W	0	68.54	64.40	65.84	72.50	72.32	75.56	64.04	53
	Algiers, -	36 48	3 1 E	0	69.98	61.52	65.66	80.24	72.50	82.76	60.08	54
Isothermal Bands above 77°.	* Cairo, -	30 2	31 18 E	0	72.32	58.46	73.58	85.10	71.42	85.82	56.12	55
	* Veracruz, -	19 11	96 1 W	0	77.72	71.96	77.90	81.50	78.62	81.86	71.06	56
	* Havannah, -	23 10	82 13 W	0	78.08	71.24	78.98	83.30	78.98	83.84	69.98	57
	* Cumana, -	10 27	65 15 W	0	81.86	80.24	83.66	82.04	80.24	84.38	79.16	58

[1] Coast of Labrador. Two years of observations. Floating ice towards the east. A transatlantic climate. Mean temp. of Oct. about 32°.72; Nov. 26°.68.

[2] Centre of Lapland. A European climate. Fine vegetation. June, 49°.46; July, 59°.54; Aug. 55°.94; Sept. 41°.74; Oct. 27°5; Nov. 12°.38. Inland situation. Specimen of a continental climate.

[3] Eleven years of observations, calculated afresh in decads by Wahlenberg. Thermometer verified by Saussure. Mean temp. of seven months of the year below 32°. Winds blow from Italy in the winter. *Minimum* observed in the winter —0°.4; in Aug. at noon, in the shade, *maximum* 54°.5; the nights in Aug. frequently from 33°.8 to 29°.8; the mean temp. of Oct. 31°.1 represents that of the whole year; at the Col de Géant, 10,598 feet high, the mean temp. of July is 36°.5. We find 32° to be the mean temp. in Europe in 45° of latitude, at 5,400 feet high; at the parallel of the Canaries, at 12,300 feet; in the Andes, under the Equator, at 16,500 feet.

[4] Buch, *Voy. en Norw.* ii. 416. Specimen of the climate of the islands and coasts in the north of Europe. April, 30.°02; May, 33°.98; Oct. 32°; Nov. 25°.88. At Alten, Lat. 70°, mean temp. of July, 63°.5; a continental climate.

[5] Finland, eastern coast. May, 40°.82; June, 55°.04; July, 61°.52; Aug. 56°.66; Sept. 46°.58; Oct. 38°.66; Nov. 24°.62. Julin and Buch.

[6] Eastern coast of Western Bothnia. Dr Nœzen. March, 23°.18; April, 33°.98; Oct. 38°.12; Nov. 24°.62.

[7] Euler. Mean temp. of the year, 37°.94. Inochodzow. *Acta. Petr.* xii. 519,—533.

[8] Two years. Berlin, in the *Mem. de l'Acad. de Drontheim,* iv. 216. April, 34°.34; May, 50°.74; Oct. 39°.2; Nov. 27°.68. Climate of the west coast of Europe.

[9] Four years. *Journal de Phys.* xxxix. 40. A continental climate. Winter colder, and summer warmer than at Petersburg. Eastern part of Europe; height as taken from Stritter. (Chamouni, Lat. 46° 1′; Long. 6° 18′ E.; height, 3,168 feet; mean temp. 39°.2.)

[10] Twelve years. Kirwan. Cotte, mean of the year, 41°.18; of the summer, 67°.46; too high. West coast of Finland.

[11] Observations from 1774 to 1804, made by Mallet, Prosperin, Holmquist, and Schleling, calculated by M. De Buch, *Voy. de Norw.* ii. 309. It is, perhaps, the place the mean temp. of which is the best determined. Winters more serene than at Stockholm; colder on account of the radiation of the ground and the air.

[12] Thirty-nine years of observations, 15 of which are very good. Wargentin. Cotte, mean temp. of the year, 44°.24. Five months below 32° as at Petersburg.

[13] Four years. A transatlantic climate.

[14] Buch, two years. Mean temp. of the winter often scarcely 31°.1. West coast.

[15] Alps of Bavaria. Six years' observations, calculated by M. Wahlenberg. Many fruit trees. Convent of Tegernsée, in Bavaria, height of, 2,292 feet; mean temp. of 1785, 42°.44; Peyssenberg, 41°.

[16] Bugge. Three months below 32°. Under the Equator, mean temp. of 44°.6, at an elevation of 18,000 feet.

[17] Dalton. West of England. Climate of islands; springs 47°.84. Keswick, Lat. 54° 33', Long. 3° 3' W.; mean temp. 48°.02; springs, 48°.56.

[18] Kirwan. Scarcely two years' observations. Southern latitude.

[19] Strnadt. Fifteen years. Climate of the continent of Europe.

[20] Maier.

[21] Six years' observations of M. Escher, calculated by Wahlenberg. The town is situated in a hollow, to which those warm winds cannot penetrate, that render the winters more temperate in the other parts of Switzerland.

[22] The calculation has been made from six years of excellent observations, by Professor Playfair; during this time the thermometer was never seen above 75°.74 *. Vegetation continues from March 20. to Oct. 20.; mean temp. of these seven months is from 55°.76 to 50°.90, according as the years are more or less fruitful; wheat does not ripen if the mean temp. descends to 47°.66.

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* See *Edinburgh Transactions*, vol. ix. p. 209.—Ed.

[23] Guittard. Only three years. Mean temp. a little too high. Eastern part of Europe. A continental climate.

[24] Four years of observations, by M. de Salis Sewis, calculated by M. Wahlenberg. Mountains of the Grisons.

[25] Kirwan. *Irish Trans.* viii. 203. and 269. Specimen of the climate of the islands. Coldest days, 23°; interior of the ground, 49°.28. Hamilton.

[26] The climate of Berne is a continental climate, in comparison with that of Geneva; there is no lake near it.

[27] Seven years of observations. Saussure. Mean temp. 50°74. *Voy.* § 1418. I find the mean temp. from 1796—1815, 49°.7. Interior of the earth, 51°.98. Pictet, *Bibliotheque Brit.* 1817, iv. 109.

[28] Six years.

[29] Austria. Berlin, Lat. 52° 31′; mean temp. probably 46°.4 to 47°.3; according to Beguelin, 48°.74; springs, 49°.28. Ratisbon, Lat. 49°; height, 1,104 feet; mean temp. 47°.66. Munich, Lat. 48° 8′; height, 1,608 feet; mean temp. 50°.74.

[30] Ramond. Seven years of excellent observations. The mean of the months, at noon, well ascertained; winter, 39°.92; spring, 57°.02; summer, 70°.88; autumn, 57°.92. *Mem. Inst.* 1812, p. 49. Cotte, mean temp. 51°.26.

[31] Wahlenberg, *Flor. Carp.* p. 90. Continental climate. Height of the observatory, 474 feet.

[32] Two years, near Boston, in New England. Transatlantic climate. The thermometer sometimes descends to 0°.

[33] Eleven years (1803—1813) of observations made at the observatory. A greater number of years will, perhaps, give the mean temp. a little higher. Vaults, 53°.06. Kirwan finds for Paris, from seven years of observations of unequal value, 51°.62; he fixes upon 52°.7. Cotte, from 29 years of observations, (*Journ. de Phys.* 1782, July), 53°.24. Cotte, for 33 years, (1763—1781, *Mem. Instit.* iv. 266.), 52°.34. The extraordinary year of 1816 offers the mean temp. of 48°.74; winter, 37°.04; spring, 48°.92; summer, 59°.54; autumn, 50°: the preceding year, 1815, offers a mean temp. of 50°.74; winter, 37°.04; spring, 52°.7; summer, 62°.78; autumn, 50°.74. Arago. Mean temp. of Montmorency, for 33 years, 50°.74; height, 498 feet. Cotte,

Strasburg, Lat. 48° 34′; height, 480 feet; mean temp. 49°.28. Herrenschneider.

[34] Dr Young. Mean temp. varies from 47°.84 to 51°.62, (*Lectures*, ii. 453.) Cavendish, (*Trans.* 1788, p. 61.), 48°.74, Roebuck, Hunter, and Kirwan, 51°.62. Horsley, 51°.26. According to Kirwan, the four seasons in London are, 39°.56, 50°.9, 64°.76, 51°.98; at Paris, 36°.68, 51°.08, 65°.84, 52°.52; from which results, London, 51°.62; Paris, 51°.44. Cotte (*Journ. de Phys.* xxxix. 36.) thinks London is 51°.26, and Paris, 52°.34. The difference which we observe in cultivated plants depends less upon mean temp. than upon direct light, and the serenity of the atmosphere.

[35] Seven years. Cotte. Lisle, 48°.38; Rouen, 51°.44; Cambray, 51°.98; Soissons, 53°.42; Rethel, 53°.24; Metz, 52°.88; Nancy, 51°.98; Etampes, 51°.08; L'Aigle, 50°.9; Brest, 54°.14; Mayenne, 51°.98.

[36] Mohr, and Van Swinden. Five years.

[37] Thirteen years. Temperature rather too high?

[38] Eleven years. Van Swinden. From 1771—1783. Mean temp. 51°.26.

[39] Concave transatlantic summit. Seven years of observations give 54°.86; for the four seasons, 33°.98, 53°.06, 75°.2, 56°.12. Rush, 52°.52, (Drake's *View of Cincin.* p. 116.) Coxe, 54°.14. M. Legaux finds for 17 years, for Springmill on the Schuylkill, Lat. 40° 50′; mean temp. 53°.42. Springs, near Philadelphia, 54°.86, Warden.

[40] Two years only. Retif de la Serve. The thermometer sometimes descends to — 4° in the parallel of Naples! Springs, 54°.86. Ipswich, Lat. 42° 38′; mean temp. 50°. Williamsburg, in Virginia, 58°.1. Cotte and Kirwan. Transatlantic climates.

[41] Transatlantic climates west of the Alleghanys. Good observations, from 1806—1813. Col. Mansfield, (Drake, p. 93.) *Minimum* of the winter, from 5° to — 9°.4; Jan. 1797, as low as — 16°.6, for 39° latitude. *Maximum* 89°.6 to 107°.6 in the shade, without reflection; $\frac{1}{3}$ of all the winds SW.; springs near Cincinnati, 54°.32. Little snow falls; but it is abundant between Lat. 40° and 42°.

[42] Three years only. Bougourd. Dijon, height, 810 feet;

Lat. 47° 19′; mean temp. 50°.9. Besançon, height, 804 feet; Lat. 47° 14′; mean temp. 51°.26.

[43] Six years. Duplessis, and Boudan. Temperature of the summer too high? Rochelle, 53°.06; Poitiers, 52°.7.

[44] Amyot. Six years. Concave. Asiatic summit. Three months below 32°, as at Copenhagen; the summer like that at Naples.

[45] One of the best determined points. The years 1789—1812 are calculated in decads of days. Observations of the Astronomer Reggio, April, 55°.76; Oct. 58°.1. The two decads which approach the nearest to the mean temp. of the year, are, the first of April, 53°.24; and the last of Oct. 54°.68. The mean temps. for January have varied in 10 years from 24°.98 to 38°.48; those of July, from 71°.42 to 78°.44; the mean of the years, from 54°.5 to 57°.2. (Reggio, taking only 24 *maxima* and *minima* in a year for 1763—1798; mean temp. 55.4, *Ephem. Mil.* 1779, p. 82.)

[46] Ten years. Guyot. Lyons, 528 feet, 55°.76. Mafra, near Lisbon, Lat. 38° 52′; height, 600 feet; mean temp. 56°.3, too small. *Mem. de Lisbonne*, ii. 105—158.

[47] Seven years, (1777—1782). St Jacques de Sylvabelle. The thermometer sometimes descends to 23°. Cotte, *Traité de Met.* ii. 420.) 34 years (Raymond, in *Mem. de la Soc. de Med.* 1777, p. 86.) give 62°.06. Cotte (*Journ. de Phys.* xxxix. 21.) fixes it at 58°.64. Kirwan, at 61°.24. The observations made at the Royal Observatory of Marseilles can alone decide.

[48] Ten years. Nismes, 60°.26; Perpignan, 59°.54; Tarascon, 59°.9; Arles, 59°; Rieux, 57°.2: Montauban, 55°.58; Tonains, 54°.86; Dax, 54°.14; Rodez, 57°.02; Aix, 56°.66. Under the equator, 57°.74, at 9,000 feet of elevation.

[49] William Humboldt. Calandrelli, 60°.08. The thermometer sometimes descends to 24°.5, and rises to 99°.5. Naples, 67°.1; Toaldo, probably 63°.5; Florence, 61°.52; Tartini, too high; Lucca, 60°.44; Genoa, 60°.26; Bologna, 56°.3; Verona, 55°.76; Venice, 56°.48; Padua, 56°.3. Kirwan regards it as an established fact, that in Europe the mean temp. in Lat. 40°, is 61°.88; in Lat. 50°, 52°.52.

[50] Only two years. Barberet, and d'Angos. Sheltered by mountains. Estimate a little too high.

[51] Japan. A single year. *Voy. de Thunberg*, p. 121. Climate of islands. Under the Equator, 64°.4, at a height of 6000 feet.

[52] West of the Alleghanys, in Louisiana. Four years. Dunbar. Transatlantic climate.

[53] Madeira. Heberden. Climate of islands. St Croix, of Teneriffe, 71°.42. The remainder of the island of Teneriffe, in the plains, 69°.26. Buch.

[54] Old observations of Tartebout. They appear good. Bagdad, Lat. 33° 19′; according to Beauchamps, 73°.76. The four seasons, 50°.74; 74°.64; 92°.66; 77°; but there was reflection from a house. The thermometer falls to 29°.44. Under the Equator, at 3,000 feet high; mean temp. 71°.24.

[55] The calculations are made from the observations of Nouet, (*Decade*, ii. 213.) The following are the mean temps. of the 12 months: 58°.1; 56°.12; 64°.58; 77°.9; 78°.26; 83°.66; 85°.02; 85°.82; 79°.16; 72°.32; 62°.96; 61°.24. (Niebuhr, 72°.2.) Temp. of Joseph's Well, 72°.5. Catacombs of Thebes, 81°.5. Well of the great pyramid, surrounded by sand, 88°.16. Jomard. Bassora, on the Persian Gulf; mean temp. 77°.9; winter, 64°.04; summer, 90°.86; July, 93°.2.

[56] Orta. Humboldt, *Nouv. Esp.* iv. 516. Jamaica, coast, 80°.6. Blagden.

[57] Ferrer, 1810—1812. *Con. des Tems*, 1817, p. 338. Wells of 10 feet deep; air, 75°.92; water, 74°.48; in 1812, *maximum*, Aug. 14. 86°; *minimum*, Feb. 20. 61°.52. Grottos, 81°.5. Humboldt, *Observ. Astron.* i. 134.

[58] Humboldt. Pondicherry, 85°.1; Madras, 80°.42; Manilla, 78° 08; Isle de France, coast, 80°.42.

Art. VI.—*Description of Water-Spouts observed by the late* Mr Maxwell. Extracted from his MS. Journal.

The appearances exhibited by water-spouts have been long ranked as among the most curious and perplexing phenomena in meteorology. Some philosophers have regarded water-spouts as of electrical origin; while others have considered them as

ART. VII.—*On the Diminution of the Obliquity of the Ecliptic.*

THE many different opinions which have for the last century prevailed concerning the quantity of the secular diminution of the obliquity of the ecliptic, and the great variety which appears in the result of modern observations, renders this subject peculiarly interesting. M. Delambre (see the Preface to the last Solar Tables) makes it upwards of 52″, according to the calculations of Laplace. Lalande, in his Tables, used 50″, but remarks that 33″ appeared to make most of the observations he had examined agree; while, on the other hand, Mr Pond very justly asserts, that it is little more than 40″, (*Nautical Almanack*, 1818). After examining all the observations registered in the various works of Long, Lalande and Delambre, 42″.697 appeared to reconcile most of the modern observations, though it is considerably smaller than what those of Pythagoras, Eratosthenes and Ptolemy would appear to sanction. But then it must be considered how liable these observations were to error. They generally adjusted their instruments, by comparing them with the meridian altitude of the sun at the vernal equinox, from which time, till the solstice, they stood exposed to all accidents. Their sinking, and the inaccuracies resulting from the badness of the divisions, made their observations susceptible of very little accuracy.

From a slight modification of Laplace's formula, we have the following theorem for finding the mean obliquity at any time.

$$\text{Mean Obliquity} = 23^\circ\ 28'\ 18''.349 - 1950''.6 \sin^2 \left\{ t\, 6''.973 \right\} - 2740''.347 \sin \left\{ t\, 32''.11575 \right\}.$$

where t is the time from 1750; it is negative before, but positive after this epoch.

The following Table is constructed from this formula, and is accompanied with a comparison of the results which it gives with those of modern observations:

Year.	Obliquity.	Diff.	Year.	Obliquity.	Diff.	Year.	Obliquity.	Diff.
	° ′ ″	″		° ′ ″	″		° ′ ″	″
400	23 43 8.8		900	23 34 18.4	41.9	2200	23 24 56.0	42.8
300	23 42 29.3	39.5	1000	23 33 36.4	42.0	2300	23 24 13.2	42.8
200	23 41 49.6	39.7	1100	23 32 54.3	42.1	2400	23 23 30.4	42.8
100	23 41 9.6	40.0	1200	23 32 12.1	42.2	2500	23 22 47.6	42.8
0	23 40 29.4	40.2	1300	23 31 29.8	42.3	2600	23 22 4.9	42.7
100	23 39 49.0	40.4	1400	23 30 47.4	42.4	2700	23 21 22.2	42.7
200	23 39 8.3	40.7	1500	23 30 4.9	42.5	2800	23 20 39.5	42.7
300	23 38 27.4	40.9	1600	23 29 22.3	42.6	2900	23 19 56.9	42.6
400	23 37 46.4	41.0	1700	23 28 39.7	42.6	3000	23 19 14.3	42.6
500	23 37 5.2	41.2	1800	23 27 57.0	42.7	3100	23 18 31.7	42.6
600	23 36 23.7	41.5	1900	23 27 14.3	42.7	3200	23 17 49.2	42.5
700	23 35 42.1	41.6	2000	23 26 21.6	42.7			
800	23 35 0.3	41.8	2100	23 25 38.8	42.8			

		Observed.	Table.
		° ′ ″	° ′ ″
818,	Almamon, (according to Golius),	23 35 0	23 35 7.8
1437,	Uleigh Beigh, - -	23 30 27	23 30 31.7
1587,	Tycho Brahe, - -	23 29 30	23 29 28.0
1653,	Hevelius, (see Long's Astronomy),	23 29 0	23 28 59.7
1672,	Cassini, (Vince's Astron. vol. i.),	23 28 54	23 28 51.7
1672,	Richers, Rees' Encyclopædia,	23 28 51.5	23 28 51.7
1736,	Condamine, - -	23 28 24	23 28 24.5
1750,	De la Caille, Bradley, Mayer, } mean of their results,	23 28 18.33	23 28 18.35
1755,	Bradley, - - -	23 28 15.5	23 28 16.2
1769,	Maskelyne, - -	23 28 10	23 28 10.2
1769,	Cerstners, - -	23 28 11	23 28 10.2
1772,	Maskelyne, (Phil. Tr. 1773, p. 93.)	23 28 8.7	23 28 8.95
1786,	Lalande, - -	23 28 0	23 28 2.99
1800,	Delambre, - -	23 27 57.0	23 27 57.00
1811,	Groombridge, (these are reduced to Jan. 1.), -	23 27 51.15	23 27 52.30
1812,	——————— - -	23 27 51.42	23 27 51.88
1818,	Pond, - -	23 27 52.01	23 27 51.88
	Brinkley, - -	23 27 51.00	23 27 51.45
1821,	———— (Dublin Magazine),	23 27 48.45	23 27 48.47

The error in the above seldom amounts to a second; and when it does amount to more, the greatness of the error can easily be accounted for. The following Tables were calculated to find the apparent obliquity from the mean at any time. The first contains the mean diminution for any number of years. The second contains the correction for days of the year, from the formula $-\frac{0''.427\,n}{365} + 0''.4345 \cos 2 \odot$; and the last contains the Lunar Nutation; the greater axis being 9″.64, which is the number Gauss and Delambre used, (see the Table at the end of Woodhouse's Astronomy, vol. i.

TABLE I.

Years.	″
0	0.00
1	0.43
2	0.85
3	1.28
4	1.71
5	2.13
6	2.56
7	2.99
8	3.41
9	3.84
10	4.27
20	8.54
30	12.80
40	17.07
50	21.34
60	25.61
70	29.87
80	34.14
90	38.42
100	42.69

TABLE II.

		″			″			″
January,	1	— 0.41	May,	1	— 0.08	September,	1	+ 0.04
	7	— 0.38		7	— 0.17		7	+ 0.09
	13	— 0.32		13	— 0.27		13	+ 0.12
	19	— 0.26		19	— 0.35		19	+ 0.13
	25	— 0.17		25	— 0.43		25	+ 0.13
February,	1	— 0.09	June,	1	— 0.51	October,	1	+ 0.10
	7	— 0.00		7	— 0.57		7	+ 0.06
	13	+ 0.08		13	— 0.61		13	+ 0.01
	19	+ 0.16		19	— 0.63		19	— 0.07
	25	+ 0.23		25	— 0.63		25	— 0.15
March,	1	+ 0.27	July,	1	— 0.64	November,	1	— 0.26
	7	+ 0.31		7	— 0.59		7	— 0.36
	13	+ 0.34		13	— 0.55		13	— 0.45
	19	+ 0.35		19	— 0.49		19	— 0.55
	25	+ 0.33		25	— 0.43		25	— 0.63
April,	1	+ 0.30	August,	1	— 0.33	December,	1	— 0.71
	7	+ 0.25		7	— 0.25		7	— 0.77
	13	+ 0.18		13	— 0.17		13	— 0.81
	19	+ 0.10		19	— 0.10		19	— 0.84
	25	+ 0.02		25	— 0.03		25	— 0.84

TAB. III.—Lunar Nutation.—Arg. Long. Moon's Node.

	O. + VI. —	I. + VII. —	II. + VIII. —	
°	″	″	″	°
0	9.64	8.35	4.82	30
1	9.64	8.27	4.62	29
2	9.64	8.18	4.53	28
3	9.63	8.09	4.38	27
4	9.62	8.00	4.23	26
5	9.61	7.90	4.08	25
6	9.59	7.81	3.92	24
7	9.57	7.71	3.77	23
8	9.55	7.60	3.61	22
9	9.53	7.49	3.46	21
10	9.50	7.39	3.30	20
11	9.47	7.28	3.15	19
12	9.44	7.17	2.99	18
13	9.40	7.06	2.83	17
14	9.36	6.94	2.67	16
15	9.31	6.82	2.50	15
16	9.27	6.70	2.33	14
17	9.22	6.58	2.17	13
18	9.17	6.46	2.01	12
19	9.12	6.33	1.85	11
20	9.07	6.20	1.68	10
21	9.01	6.07	1.52	9
22	8.95	5.94	1.35	8
23	8.88	5.81	1.18	7
24	8.81	5.67	1.01	6
25	8.74	5.53	0.84	5
26	8.67	5.40	0.67	4
27	8.60	5.25	0.50	3
28	8.52	5.11	0.33	2
29	8.44	4.97	0.17	1
30	8.35	4.82	0.00	0
	V. — XI. +	IV. — X. +	III. — IX. +	

To find the True Obliquity from these Tables, subtract from 23° 27′ 57″.00, the number answering to the number of years after 1800; and then add or subtract, according to its sign, the numbers from the two last Tables.

Example.

Required to find the Apparent Obliquity April 12. 1821?

		° ′ ″
		23 27 57.00
Table 1. 20 years,	-	— 8.54
——— — 1 year,	-	— 0.43
Table 2. April 12.	-	+ 0.19
Table 3. Moon's Node, 11ˢ 11° 41′,	-	+ 9.15
The Apparent Obliquity,		23 27 57.37

R. T.

Belfast, *April* 12. 1821.

ART. VIII.—*Observations on the Countries of Congo and Loango, as in* 1790. By Mr MAXWELL, Author of the Letters to MUNGO PARK, &c. &c. (Continued from Vol. IV. p. 331.)

Religion.—IT is difficult, if not impracticable, to form a just idea of the state of religion among a people of whose language we know so little. It is chiefly, indeed, from fortuitous circumstances that we are to seek for any information on the subject. To exemplify this, Monsieur Deshay, and several traders, were one day dining with me, when a French boat, belonging to an Indiaman, lying at Cape Padroon, sent to sound and explore the river, came alongside. The officer commanding the boat, said that his ship would be at Embomma in ten or twelve days. In other circumstances, this intelligence would have alarmed me a good deal, for these ships are always provided with very expensive and commanding cargoes; but, having nearly completed my purchase, I carelessly observed to Captain Deshay, that it was of little consequence to me, as I should have done by that time. "He bien!" says he, "Soleil s'eleve pour tout le monde;" as much as to say, he would not be idle. The natives, who had a smattering both of French and English, were much puzzled with the phrase, and could not possibly make out its meaning or application. Many ludicrous explanations were given, until Prince Nefoomu Emfoote observed to me,—"Cappy!—I'll tell you what I tink Sun be,—I think Sun be Enzambi Empoongu's chief mate!"

From all that I have been able to collect on a subject so interesting, there appears to be a prevailing belief in this part of Africa, that the affairs of the world are governed by an invisible being of infinite wisdom and power, whose every scheme tends to the welfare and happiness of his creatures. They look upon the Sun as his prime agent in carrying on the operations of nature, without whose genial influence, darkness and desolation would cover the face of the earth. The chief mate of a ship, they remarked, carried all the Captain's orders into execution, without the appearance of the Captain himself, which no doubt led Nefoomu Emfoote to make use of his very judicious

simile, as most expressive of the meaning he attached to Deshay's remark.

As another example :—Having unbound a slave whom I had purchased; he threw himself into an attitude of devotion, and casting his eyes upwards, ejaculated, "Enzambi Empoongu,—Menou moontu accu!"—God Almighty,—I am thy creature! then looking cheerfully in my face, he took a pipe from his belt, and shewed me that it was empty. I gave him some tobacco and biscuits, with which he seemed highly gratified, and from that time he became a great favourite on board.

These incidents shew, that important conclusions may be drawn from a careful observation of the common occurrences of life in an uncivilised state of society; and that, amid a profusion of absurdities intermingled with their worship, the inhabitants of Congo have some elevated conceptions of a Deity, whom they worship under the name of Enzambi Empoongu. Notwithstanding the assertions of certain travellers and voyagers to the contrary, I can scarcely think that there is, or ever was, a nation, however barbarous, altogether destitute of belief in the existence of a Supreme Being, and of a future state.

Boonzie, whose mandates are obeyed, as though they were the decrees of fate, is held in peculiar veneration. When the whirlblast is seen sweeping alongst the plain, raising, in circular eddies, chaotic masses from the ground,—they exclaim,—"It is the spirit of Boonzie!" and fly from its course with terror.

Fitishes.—Were it not our duty to bring the absurdities of the uncultivated savage mind, as well as the endowments of philosophy, under review, these evidences of mental degradation would be undeserving of notice. *Fitish* is the appellation for an Idol of whatever kind; and they are of endless variety in form, composition, and virtue. The most common are milk, eggs, and birds. Among the latter, the partridge is held so sacred, that if the foot of a dead one is known to have touched a dish of meat, however much esteemed, no one will taste of it, although ready to die of hunger. But they do not regard milk or eggs with equal veneration, or rather horror, for I have seen three or four parties at the cabin table devouring each others fitishes with the greatest harmony.

Their portable fitishes consist of rude imitations of the human form, and of animals, with a piece of looking-glass fixed

in the breast; the tusks of the young elephant, filled with a black paste, into which shells are stuck; tigers claws and teeth; the minute horns of the chevrotten and other animals; sea-shells full of black paste; to which may be added, small parcels of party-coloured rags, little bags of precious ingredients, and diminutive flasks containing consecrated gunpowder.

No man takes a drink, without making an oblation to the master Fitish, which is frequently an elephant's tooth. He holds it in the left hand, and after licking its pasted head with his tongue, squirts a mouthful of liquid over it in a shower; then muttering a few words, he pours what remains into the dish in which it was presented to him, or from whence he took it.

Malemba.—The King of Chimfooka, (or Malemba), is not permitted to trade, or visit sea-ports, but is obliged to reside in a remote part of the country with the priesthood, to superintend the great depot of their religious establishment, and guard the sacred asylum of the Fitishes. He is not allowed to wear foreign manufactures, but must be content with a dress made of the coarsest grass-cloth. So very scrupulous are they in this respect, that none of the Princes are permitted to approach the King in a dress dissimilar to his own; and even European officers, when on visits of ceremony, and accompanied by presents for the King, are under the necessity of complying. These, in conjunction with other customs, are productive of great hesitation among the nobles, when the throne becomes elective, through failure of the male line, who shall become a recluse, and submit to the drudgery and privations of the kingly office. This sometimes occasions an interregnum of many years, as happened to be the case, when I was there in 1785. Mambooka was the only candidate for the vacant throne; but being a man of immense power and wealth, and extensively engaged in a lucrative trade, he contrived to amuse the nation, and stave off his inauguration for several years; so unwilling are they to relinquish the advantages and enjoyments of commerce, for the austerities and mortifications of royalty. Mambooka, it would appear, considered "the kingly couch no better than a watch-case, or a common 'larum-bell;" and happy perhaps might it be for mankind, had the office nowhere greater charms.

Were it not for the numerous restrictions under which the King of Chimfooka labours, there would be nothing extraordinary in his having, as is confidently asserted, five hundred wives; for polygamy prevails over almost all those portions of Africa with which we are acquainted.

The titles of dignity under the King are, Macheila,—Makai,—Mambooka,—Mamfooka,—Machainghe,—Mabaillie,—and Foomu. The two first of these belong to the presumptive heir of the Crown, and are therefore next to that of King, the highest dignities in the kingdom; but Mambooka, the viceroy, having the command of the forces, or, rather, the privilege of assembling and employing armed men, (for regular troops they have none,) is by far the most powerful. Mamfooka, or Mafooka, as he is generally called, is collector of the customs; which, if we may judge from the great interest and caballing, amounting sometimes to petty warfare, employed in canvassing for it, is a very lucrative post. Machainghe and Mabaillie are inferior officers to Mafooka, and of little note, except in conducting the supplies of wood and water, for which they exact a small duty from the shipping. Machainghe has commonly a quantity of fire-wood ready cut, which he sells at a moderate price. It is mostly mangrove, which splits freely, and burns well, but at the same time emitting a very pungent smoke, which frequently brings on that very distressing and obstinate complaint, Ophthalmia. Foomu is the usual designation of Prince.

It is impossible to understand, from a casual observance of their effects, the springs and movements of a government like this, so as to make the several parts bear upon each other, and exhibit that regularity of design which, to a certain extent, no doubt exists, and which might, with care and attention, be traced. However barbarous and uncivilised a nation may be, we generally find, on minute inquiry, that the few have ever had sufficient ingenuity and address to systematize tyranny, and forge shackles for the minds, as well as for the bodies, of the many; and in such a state of society, the multitude is a patient animal, which unresistingly yields its neck to the yoke.

Burials.—In Angoya and Chimfooka, when a great man dies, his remains are kept in state for a period proportioned to

the wealth and rank of his family: Thus, the body of a Prince is denied the rite of inhumation during the space of four years. But in Loango proper, eighty miles to the northward, the dead are baked upon hurdles over a slow fire of aromatic wood. How they are disposed of afterwards, I could not learn.

In the former case, the body is constantly attended by hired mourners, who at intervals utter dismal howlings and lamentations. They tear their hair and puncture their bodies in the most extravagant manner, as if under the influence of excessive grief; and interpolate the fictitious song of sorrow for the deceased, with eulogies on the greatness of his lineage, his wealth, bounty, strength, wisdom, and valour. They are occasionally employed through the day in shrouding the body, which is supported in an erect position in the centre of a house appropriated to the purpose; first, with grass-cloths, fold over fold, each piece being fastened to that immediately beneath, and, last of all, with European and Asiatic manufactures, web over web in a similar manner, until it arrives at an enormous bulk. These envelopes of costly materials;—chintz, taffetas, brocades, &c. are sometimes carried to the ruinous extent of two hundred cubic feet, exhibiting the appearance of an oblong package, with a protuberance arising from the midst of the upper surface. To retard putrefaction, some gallons of brandy are daily poured upon the fabric, which, after percolating through it, is collected in troughs, and quaffed off by the attendant mourners, as the most delicious and renovating beverage in nature. It acts like a charm, for their songs immediately assume a loftier strain of woe. Thus, for the space of twelve months were conducted the obsequies of a Malemba trader,—Empollo Leumba,—a worthless character, whose wealth, great alliances, and vanity, procured him that outward respect and honour which his countrymen secretly denied him. His ears were cropped for some misdeed of his youth, and his countenance bespoke the insidious betrayer. I was present at the conclusion of the solemnities.

Among the thousands who thronged to his funeral, ardent spirits were distributed with an unsparing hand, which doubtless was the chief cause of their attendance. The corpse, pla-

ced on a low open bier, moving upon small wheels, was, with the assistance of ropes, dragged by the assembled multitude to the grave,—a hole twelve feet deep. In this was an immense wicker basket, ready to receive the shrouded body, which being lowered into it by cords, the lid was closed, and the whole covered with earth; finally, two large elephant's tusks were placed over the head. A pathway led through the hollow dell, where the burial ground lay, and we may conclude, that the repository of the dead is held sacred, since the natives resist the strong temptation to open them offered by the great quantities of ivory deposited in these places.

One of the traders shewed me a spot where he once saw a lion devouring an antelope, and I must needs say, the valley, from its awful retirement, seemed a suitable haunt for the monarch of the forest.

Kingdom of Congo.—If the testimony of the natives may be relied on, the countries of Chimfooka, Angoya, Embomma, Loango proper, Solongo, and Sonia, at no great distance of time, formed part of the kingdom of Congo, the capital of which, from time immemorial, has been Banza Congo, (now St Salvador). Upon the seizure of the city by the Portuguese, and the consequent paralysation of the power that upheld the kingdom, a number of independent states arose from the ruins, and whatever progress civilization might have made among them before that event, they have since remained in their present barbarous condition. It cannot, however, be thought that the great kingdom of Congo, which comprehended, in addition to those already mentioned, the very extensive countries of Angola and Benguela, was ruled with the mental weakness and imbecillity, characteristic of these governments at present.

Every one speaks in praise and admiration of the City of Congo,—its situation and extent,—the power and grandeur of the King before the arrival of the Portuguese.

Sonia.—The people of Sonia, it is said, were obliged to carry burdens of white sea-sand from the beach to Banza Congo, one hundred and fifty miles distant, to form pleasant walks at the royal residence. This at last so exasperated the Sonia men, whose warlike and independent spirit is feared and respected by all the neighbouring nations, that they concealed

their weapons in the burdens of sand, and were, by this contrivance, enabled to avenge themselves of the indignity put upon them, by plundering the city and killing many of the King's people.

Having thus shaken off the yoke, Sonia has since been governed by native Princes.

However extravagant the idea of carrying burdens of sand such a distance may appear, yet the history of all barbarous and despotic nations, in some measure warrants the authenticity of the fact; for there, we see slaves subjected to ignominious tasks disproportioned to their strength and means; witness the Israelites, doomed by Pharoah to make bricks without the necessary materials. Unless founded on fact, it is hard to conceive how the story could have originated among a people who at present know not the luxury of artificial walks.

It is worthy of remark, that the shoulder load is admirably calculated for the artifice of concealing arms, being nearly five feet long, and about eight inches square. It is formed by means of a bamboo or palm branch, which although very light and slender, is strong enough to support and keep the packages extended, whilst they are firmly bound to it by a peculiar sort of long narrow leaves. In this manner, parcels of salt and other small articles, are always brought to the Embomma market.

Many wonderful stories are related of the courage and ferocity of the Sonia men. When one of them is taken prisoner, which, it is admitted, very seldom happens, he endeavours to exasperate his perhaps already implacable enemy, by requesting that he may be dispatched with his own clean weapon, and not with the captor's dirty one;—a plain insinuation that no quarter is given.

This nation is certainly of very different habits from any other upon the coast. It has had no intercourse with Europeans for these fifty years, when, in one night, the inhabitants massacred a colony of Portuguese, (probably their first establishment in 1484,) who had, for a long period, been settled in very considerable numbers in Sonia. They had many churches and seminaries of learning, which have all been demolished, with the exception of one called Ganga Emkisse, preserved

as a monument of vengeance, now filled with bells, crucifixes, and other relics, the wreck of the colony.

Upon the whole, the stories of the invincible prowess and martial character of this nation, are entitled to some consideration. If they are somewhat embellished, we need not be surprised, for what else can be expected: yet they ought not to be regarded on that account as altogether fabulous; for, even in polished nations, every thing transmitted by oral tradition, very soon acquires a tinge of the marvellous. What I can say of the Sonia men, from my own personal knowledge, is in perfect unison with their magnanimous character; never having experienced any act of treachery or violence from them, although once completely in their power. I had strayed to some distance from the boat's crew, who were cutting grass for the live stock at sea, when a party of Sonia men travelling that way, and hearing the report of my fowling-piece, came upon me unawares, before I had time to load. I was a little alarmed, but, to put the best face on the matter, I asked the Chief if he would sell his ivory trumpets, to which partly consenting, he agreed to accompany me to the boat, where I purchased two of them, and gave him and his men something to eat and drink. They were going, they said, to Ganga Empeenda, and were quite at their ease whilst they remained at the boat, plainly shewing that they neither intended nor dreaded treachery. Before resuming their journey, they regaled us with a concert on the trumpets, as savage and discordant as the Genius of Africa could wish. The Chief had six ivory trumpets, the largest of which had apparently been a tooth of ninety pounds in weight. He had likewise a drum, and three musical instruments like lyres.

Trumpets.—Tusks of such magnitude can only belong, as may well be supposed, to the elephant. They are converted into trumpets by boring out the body of the ivory, and leaving only a thin shell at the root, increasing however in thickness towards the point, within a short space of which, according to the size of the tusk, a hole is made to communicate with the extremity of the cavity; to this, the mouth is applied when blowing. The external surface of the trumpet is highly polished, and is frequently covered with regular devices and hierogly-

phics, indented upon it with a hot iron. Upon the small end are carved a few annular knobs. The intrinsic value is small, compared with the value of labour employed in its formation. For this and their gorgeous appearance they are chiefly prized; but to instruments of music, they have not the smallest pretension.

Salutations.—When two persons of equal rank meet, one of them, kneeling on his left knee, gives the Saccula, (a certain clapping of the hands,) saying, "Katto co keile?"—How do you do?—To which the other replies in a similar manner, "Keile ma botta moine!"—Very well, I thank you Sir.

When an inferior approaches his superior to ask a favour, he prostrates himself on the ground, and, throwing dust upon his head, clapps his hands as a suppliant, and says, "—Betsawae moine, Menou Moontu accu, Menou Baveeca accu!"—Be merciful, Master, I am your servant, I am your slave!

(To be continued.)

Art. IX.—*Account of an Improved Apparatus for restoring the Action of the Lungs.* By Mr John Murray, Lecturer on Chemistry. Communicated by the Author *.

Having simplified and improved my apparatus for restoring the action of the lungs, I now beg leave to transmit you a correct sketch of it. Mr Richard Northen of Hull has constructed the machine in a very elegant manner, and I anticipate with much satisfaction its success in suspended animation. It may be also serviceable in cases of asthma.

Fig. 2. of Plate I. represents, as it appears externally, the apparatus, in which A is a stop-cock for the efflux of the heated water contained between the concentric cylinders, when the operation has closed. B, a stop-cock, with index attached to the flexible pipe, (which extends to the larynx,) to *renew* the air, which, however, will not be required, until the return of natu-

* See Vol. IV. of this Journal, p. 139. for an account of the apparatus as originally constructed by Mr Murray. We understand that *four* birds were lately recovered from apparent death by Mr Murray's process. Ed.

ral respiration. When the index points in the direction of the lungs, or parallel with the pipe, the communication between the lungs and cylinder is open; and when at right angles, that with the lungs is shut, and the cylinder then communicates only with the free atmosphere. Hence, when the piston-rod is raised, and the index points to the lungs, the canal being open, the air reposing on the lungs passes to the cylinder; and when the index is moved the quadrant of a circle, or at right angles with the former position, the aperture which leads to the lungs is closed, and that which conducts into the free atmosphere uncovĕred; consequently, on the descent of the piston-rod, the air drawn from the lungs is expelled into the atmosphere, while a fresh supply is received on elevating the piston; and the index being turned into its former position, the descending piston propels it into the lungs, and the alternations of its movements assimilate to the beautiful isochronism of natural respiration, which is not very variable in health, unless affected by adventitious circumstances; for a pendulum vibrating seconds may be its measure. To the lateral aperture is attached a concave pan, C, somewhat resembling that of a musket, to receive a drop of *ether*, which, entering into the cylinder along with the ingress of atmospheric air, expands and diffuses itself therein on the elevation of the piston, and thus operates on the lungs with all the stimulus of nitrous oxide. In cases of asphyxia by carbonic acid gas, a drop of *ammonia* may be serviceable, while, in that of the septic poison, sulphuretted hydrogen, a solution of *chlorine* might prove of benefit. D is the orifice by which the partition is supplied with heated water.

Fig. 3. exhibits a section of the apparatus, where A is the piston-rod, accurately adapted to the cylinder in which it moves. This inner cylinder has one concentric with it which forms a partition, the recipient of the heated water; and the base which limits the descent of the solid plunger, has a simple aperture *without any valve.* B is a toothed quadrant attached to a lever, and moving on a fulcrum, for the purpose of elevating and depressing the piston. C is a check which regulates the altitude of the piston; and thus apportions its elevation to the capacity of the lungs, whether the subject be an adult or of tender age. D is a partition surrounding the inner cylinder, and supplied with wa-

ter at a temperature sufficient to maintain the air propelled into the lungs at the *usual animal temperature*, of 98° Fahr. E represents a thermometer for more accurate adjustment, and F, a pipe communicating with the interior cylinder, and to which the flexible tube is attached.

ART. X.—*Account of the Rousts or Currents of Tide in the Pentland Frith, &c.* from the Manuscript Journal of the late Reverend GEORGE LOW of Orkney. With Preliminary Observations by SAMUEL HIBBERT, M. D. F. R. S. E. &c. &c.

THERE are probably no natural phenomena incidental to the islands of the North of Scotland, that have more attracted the attention of the few naturalists who have visited this remote district of Britain, than the various and opposite directions of the tides. There is, for instance, bearing off the most southerly extremity of Shetland, named Sumburgh Head, what is termed in the provincial phrase of the country, *a roust*,—this being a word of Scandinavian origin, used to signify a strong tumultuous current, occasioned by the meeting of rapid tides *. When the sea is calm, there is the appearance of a turbulent stream of tide, about two or three miles broad, in the midst of smooth water, extending a short distance from Sumburgh, and then gradually dwindling away, so as to terminate in a long slender dark line, bearing towards Fair-Isle. I believe that appearances like these have generally met with less attention than is due to their importance, and the investigation of them may, perhaps, be satisfactorily prosecuted in reference to the concise statement which has been given by Mr Playfair, of the causes of the British tides that are propagated from the great diurnal undulations of the Atlantic. "The high water transmitted from the tide in the Atlantic," says this author, "reaches Ushant between three and four hours after the moon has passed the meridian, and its ridge stretches N. W., so as to fall a little south

* Isl. *roest*, *raust*, æstuaria, vortices maris, Verel, Ind. Supposed by one author to be synonimous with the A. S. *rase*, stridor, impetus fluvii.—See Jamieson's Etym. Dict. word *roust*.

of the coast of Ireland. This wave soon afterwards divides itself into three; one part passing up the British channel, another ranging along the west side of Ireland and Scotland, and the third entering the Irish channel. The first of these flows through the channel at the rate of about 50 miles an hour, so as to pass through the Straits of Dover, and to reach the Nore about twelve at night. The second being in a more open sea, moves with more rapidity; by six it has reached the north extremity of the Irish coast; about nine it has got to the Orkney islands, and forms a ridge or wave extending due north; at twelve, the summit of the same wave extends from the west of Buchan eastward to the Naze of Norway; and in twelve hours more it reaches the Nore, where it meets the morning tide, that left the north of the channel only eight hours before *." The explanation, then, of the opposition of tides or *Roust*, as it is named at Sumburgh Head, may be given in connection with that wave of tide propagated from the great diurnal undulation of the Atlantic, which, in the progress of completing its circuit round Britain, is described as passing to the west of Orkney,—from thence to the north of the British Isles, and then taking a southerly direction, so as to form a ridge that extends between Buchan and the Naze of Norway. The tides of Shetland appear to be induced by lesser currents, generated during the progress of the wave along the westerly, northerly, and easterly parts of the country, and these set in nearly an hour sooner on the west than on the east coast of these islands. At the beginning of the flood, the tide in the Roust is directed to the eastward, until it passes the promontory of Sumburgh; it then meets with a south tide, that has been flowing on the east side of the country; a divergement then takes place to the south-east, and lastly to the south. At high-water there is a short cessation of the tide, called the Still; then the ebb begins, first setting northwest and then north, until the recommencement of the flood. The various directions of the tides of Shetland are no doubt owing, in a considerable degree, to modifications which take place from the number and form of the various headlands and inlets of the coast; but since they are propagated at successive intervals of time, it is evident that at the northerly and southerly

* Playfair's Outlines of Natural Philosophy, vol. ii. p. 338.

extremities of the Shetland Archipelago, they would be naturally opposed to each other. A gentleman has remarked to me that he has been for five days becalmed in a sloop between Fitfiel Head and Sumburgh Head, which are distant from each other about three miles, without being able to pass either point; one current carrying the vessel into the eastern, and the other into the western ocean: the sloop was often transported by the tide very near the shore, yet another tide always carried her off again. But although there is an opposition of currents from Sumburgh to Fair Isle, and no doubt from thence to Orkney, the Roust is that part of the stream lying at a small distance from the promontory, the force of which is probably increased by its proximity to the coast, and by the shallowness of the water. Here there is always a heavy sea, but in a storm the waves are said to rise mountains high. Drayton has given a good description of the occurrence of similar phenomena at the Race of Portland, not however unmixed with a tolerable proportion of poetic bathos:

> "Some coming from the east, some from the setting sun,
> The liquid mountains still together mainly run,
> Wave woundeth wave again, and billow billow gores,
> And topsy-turvy so fly tumbling to the shores."

Having offered these preliminary remarks on the currents of tide which occur among the islands of the north of Scotland, I shall now advert to the industrious researches that were made about fifty years ago, by the Reverend George Low, an acute naturalist of Orkney, on the coasts of the Pentland Frith, the explanation of which is equally connected with the view that they arise from lesser currents generated during the progress of a wave of tide round the British Isles, setting sooner on the west than on the east coast of the Orkney group; and that, in every channel connecting the westerly and easterly seas that bound the coasts of this narrow cluster of islets, currents of tide propagated at successive intervals of time, would be naturally opposed to each other. The phenomena, then, which take place, from this cause, in the Pentland Frith, and the modifications that the currents undergo from the islands in the channel, and from the form of the coasts, constituted the object of Mr Low's inquiries; and, as the result of them has not, to my knowledge, been ever given to the public, the following account is selected from an unpublished Tour which he made through

that country in the year 1774, the MS. having recently come into my possession. For the accuracy of the observations it cannot be expected that I should be in the smallest degree accountable: but every reasonable confidence on this point may be reposed in a naturalist to whose labours the late Mr Pennant was highly indebted; and whose merits Dr Leach has justly appreciated, when he has stated, that "they were those of a laborious and accurate observer of nature, but which were scarcely known beyond the narrow circle of his particular friends *."

"In passing the Pightland Frith †, one cannot fail observing a number of currents, which appear like pretty large rivers running in the midst of dead water, and can be seen at some distance, owing to the many sounds of Orkney through which these currents proceed, and the many points and islands which break the main stream, and give fresh motion to so many new currents, which, by this new-acquired rapidity, forcing themselves a passage through the more equal course of the main tide, cause these irregularities so much wondered at. For example, the tide of flood setting from the N. W. meets with no resistance from any thing, except a few headlands in Orkney, and on the Caithness shore, till it comes to Cantick Head in Waes. There it meets a tide coming through Hoy Sound, which is broke into many streams by the Islands of Cava, Fara, Flota, Switha, and Swona, and kept in by the large island of S. Ronaldsha. The courses of all these lesser streams are quite across the great stream of Pightland Firth, but their rapidity is greater; therefore every one will occasion an alteration in the great tide; and this meeting of two contrary tides, when the water is much disturbed by it, we call a *roust*, which is often dangerous for boats, especially when the violence of the wind contributes to put the waves of that spot in a still greater rage. Again, the tide of Pightland Firth continues, in some measure, undisturbed, till it comes to Stroma, upon the north point of which, it breaks with prodigious violence, and goes off with vast rapidity, forming an amazing current, called the Swelchee; as, on the south end, the tide, by

* See Dr Leach's advertisement to Mr Low's posthumous publication, entitled the "Fauna Orcadensis."

† Pightland Frith is the name sometimes given to the Pentland Frith.

breaking the same way, and with the same force, but with ebb, form the *Merry Men of May*, currents which it is impossible to stem with sails or oars; but vessels will be hurried away by them, like feathers before the wind. A little below the neck of the stream, or where the water breaks on Stroma, it goes off in vast whirls, and forms a roust by the dancing of the stream now spread wider than before, and spending its lately acquired vigour in this tremulous motion; and if any boat be so unhappy as to be hurled down into this gulf, it is a thousand to one if it is not tumbled over and over, as the waves attack it on all sides, often mounting it on its very end, throwing the men hither and thither out of it; and, in a word, rendering it absolutely impossible for them to save themselves by any manner of slight or cunning.

" All these evils, and others, about Pightland Frith may be easily guarded against, by choosing a proper tide, which is some time before slack-water, (as it is called by the ferrymen,) *i. e.* about an hour before the high or low water, at any of which times, wind and weather favouring, the firth may be passed with great safety, as I then did, and landed at *Stroma*.

" Though this small isle does not so properly come within my province, as it is never reckoned one of the Orkneys, and has, from the earliest times, belonged to the people of Caithness, yet I was the more willing to give it a visit, as my very worthy friend Mr Pennant, in his Tour 1769, did not traverse it."

Here follows the account of the Island of Stroma, which does not belong to the present subject.

" Swona is bordered with high rocks. There are also many sharp-pointed rocks, which shoot far above water, and give this place a very formidable appearance; but with little danger, as the tides rather set a ship from, than on the coasts of the Pightland Firth Isles.

"At the north and south ends of Swona, the tide sets off with vast rapidity, as the strength of the Pightland Firth stream is broken by it; the first considerable stop it meets with both flood and ebb. This rapidity of the tide, and the depth of water, together with the particular position of the island, which exactly crosses the stream, contribute to form these whirpools called the Wells of Swona, so long famous for the alleged danger in passing over or near them.

" Much has been said concerning these wells, and different accounts have been given of them; some telling us they are occasioned " by some hiatus in the earth below;" others, " that there may be some secret conveyances through the rugged rocks into caverns at the bottom, from which they may pass into some other places, where they rise again, and that even in the same firth," &c.

" I should think the plainest account of the matter is this: The tide setting from the westward through Pightland Firth, meets with little or no resistance till it arrives at Swona, where, striking on the southermost point, it acquires new vigour, and sets off for S. Ronaldsha, with vast force; but, as it is held in on the Firth side by the main stream, and finds little or no resistance on the side towards the eddy of Swona, this must naturally cause a wheel in such a rapid current, which will immediately begin at the sharp corner of the island, and continue to whirl, in a greater or lesser degree, (according to the time of the tide,) till it gets a good distance from the island, into calmer water, and loses the velocity it had acquired at the point it set off from. This first whirl will be succeeded by another; the second by a third, and so on, as long as the stream has sufficient force to form them; and, accordingly, it is true, in fact, that this phenomenon does not appear in any degree, till the tide has acquired some strength in the sound; and, growing stronger as the tide becomes so, dies away some time before high water, when all is calm, till the turn of the tide, at which time the very same thing is repeated, and for the same reasons, at the other corner of the island. With the ebb the tide sets down upon Swona, from the S. E.; and the strength of that part of the stream running through the sounds of Flotta, &c. towards Hoy, and keeping between Swona and Barthhead, must occasion the very same thing to happen in the western eddy, as the flood did in the eastern; and this we see to be exactly the case: for the whirl sets off immediately as the tide makes for Cantick Head, in the same manner as it did before for S. Ronaldsha. Annexed is a drawing, which may help to make what has been said better understood.

" *Explanation of the Scheme, Plate* II. *Fig.* 1.

" In Fig. 1. *a*, is the main tide of the Pightland Firth; *b*, that edge of it that sets by the south side of Waes, and bears straight

down upon Swona, and that reinforced by *c c*, a part of the stream of Hoysound, which runs south by Hackness in Waes, and splits on the back of Swona, one part assisting to form the wells on the south side *h*, while the other forms a small whirl on the north end of the island *i*, the effect of which is very much taken off by *d*, a part of the stream of Switha, which sets down on S. Ronaldsha; but, meeting with resistance there, runs broad off, and falls almost parallel to the longside of the Island of Swona, and can have no such effect as the stronger current has at the other, where it strikes almost at right angles, and finds little or nothing to divert it. For, though the united streams *c c* and *d* might have some influence this way; yet this is much taken off by the course of that stream after union, as also by the shape of the island, the point *l* of which covers the wells and forms a pretty large eddy in which they play.

"At the tide of ebb (*vide* Fig. 2.) the effect will be much the same, but in a contrary direction; for here the main tide *a*, setting to the westward, part of it will be drawn by the sounds from its true direction *a a*, and run in that marked *b*, *b*, *b*, straight upon the south end of Swona *f*; but when it comes there, instead of being inclined toward the eddy, as would naturally be the case if nothing hindered, here it feels the indraught of the Waes Firth, which rather diverts it from, than turns it towards the eddy of Swona. Again, that part of the stream *b*, which is next S. Ronaldsha, being more attracted by the sound between it and Swona, and in its passage along the S. Ronaldsha shore meeting with the Lother, it springs from thence with vast rapidity, and proceeds N. W. according to the course of the sound, till it meets with the point *g* of Swona, which in some measure alters its direction, as it is at the same time drawn by Pightland Firth, but very much increases its rapidity, causing it to run off in whirls from this point of the island, in the very same manner it did at the other in the former case. This must here also necessarily happen, as the stream *c* is closely held in, as well by the draught of the Firth as by the partial current *c c*, both of which hinder it from spreading on that side; but, meeting with no resistance on the side towards the eddy, it finds itself more at liberty. However, its acquired force does not allow it to spread at once. It therefore spends this force in forming these whirls

so much wondered at; though, in a word, there is nothing so very admirable with respect to the formation of such a phenomenon as this: it must necessarily follow in every similar circumstance, and is no more to be wondered at here, than when we see, in a quick running river, an eddy formed by a rock or stone, in which such whirls are as observable as here, though in miniature, and have the very same effect on straws, and other light bodies which come within their vortices, as the wells of Swona have on small boats, &c.

"So true it is, that the same thing happens in every similar circumstance. I believe there is scarce a point among the isles where the tide comes near, and runs with rapidity, but this is observable in a greater or lesser degree; but it is particularly so at the north point of Stroma, where the Swelchee runs off with vast rapidity, and dreadful whirling, though indeed not so regular as Swona, but enough to shew that the same cause will produce the same effect.

"So much for the nature of the wells. The diameter of the whirls very much depends upon accident; for, when the wind blows hard, they are scarcely observable farther than by an irregular whirl of the tide. In a dead calm they are clearest; but, in this respect, I was something unlucky. The whole time I was on the island the wind was high, so that I could not observe the whirls so exactly formed as the boatmen told me they are wont; but the foregoing are the thoughts that were suggested to me, upon viewing the situation of the island, the run of the different tides; and the rapidity of their motions; which, whether they are just or not, must be submitted. Further observations may be made, which may clear up what is deficient in them.

"Notwithstanding the many stories we hear told of these wells, I have heard of no accident happening in them these many years; and indeed I am afraid their power of swallowing up ships, boats, &c. has been a good deal magnified: for, though I believe they might be able to overturn a very small boat, they can have no such effect on a ship, as has been often experienced by people who have fallen into them, and have indeed been hurried away by the force of the stream; but this was the greatest inconveniency they felt from them."

Art. XI.—*Notice respecting* Copernicus, *with a Plate, containing a Fac Simile of one of his Letters.*

The particulars of the life and discoveries of Copernicus have been so fully detailed by Gassendi, in his account of this great restorer of astronomy, that it would be inconsistent with the plan of this Journal to enter upon a subject so familiar to all who have studied the history of astronomy.

We have been led to introduce the subject at present, in consequence of having been indulged, through a friend, with a sight of one of the few letters that remain of that celebrated astronomer; and we have no doubt that our readers will thank us for gratifying them with a fac simile of this interesting MS.

The original letter is from the Library of Prince Czartoryski, at Putawy in Poland, who has distinguished himself by his immense collection of Polish antiquities.

The following is the original letter, as engraven in Plate III.

" Rev^me^ in Christo pater et domine. Percepi literas Reverendæ Dominationis Vestræ, e quibus humanitatem, gratiam et favorem erga me Reverendæ Dominationis Vestræ satis intelligo, quæ cum apud ipsam obtinui, etiam apud alios quoscunque bonos viros eadem mihi propagare non dedignatur. Quod certe non meis meritis sed cognitæ R. D. Vestræ bonitati puto tribuendum. Utinam mihi possit aliqua contingere quibus hæc possent promoveri. Gaudeo certe plusquam dici potest me talem dominum et fautorem invenisse. Quod autem petit R. D. Vestra ut ad se 20 hujus mensis conferrem, quod etsi libentissimus facerem non levem causam habens tantum amicum et patronum visitandi, id tamen mihi incidit infortunium ut eo tempore Dominum Felicem et me negotia quædam et causæ necessariæ nos cogant in loco manere. Itaque uti R. D. Vestra boni consulat absentiam tunc meam rogo. Sum alioquin accedere R. D. Vestram, ut par est, paratissimus, et cui plurima alia debeo facere quod placuerit, modo id R. D. Vestra alio tempore mihi insinuaverit. Cui jam non in petitis gratificari, sed magis missam ca-

pessere me debere fateor. Ex Frauemberg parasceve Paschæ, anno 1533. Erga R. D. VESTRAM,

devotissimus NICOLAUS COPERNICUS.

Revmo in Christo patri et domino, Domino Joanni Electo Culmensi, Domino et fautori suo plurimum observando, 1533.

Of which the following is a Translation.

Most Reverend Father and Lord in Christ. I have received the letter of your Reverend Highness, from which I have assurance of your Reverend Highness's kindness, favour, and friendship towards me: and these favourable sentiments I have learned both from yourself and from some other worthy men to whom you have deigned to communicate them. This, I am indeed conscious, must be ascribed, not to any merit of mine, but to the distinguished goodness of your Reverend Highness. I wish that there were any means in my power by which I could promote these favourable sentiments. I am indeed inexpressibly happy in having obtained such a protector and friend. With respect to your Reverend Highness's request, that I should meet you on the 20th of this month, though I would most willingly do this, since I have no slight reasons for visiting so warm a friend and patron; yet it happens unfortunately for me, that, at that time, some business, and weighty reasons, detain my excellent protector and me in this place. I therefore entreat your Reverend Highness to excuse my absence at that period. I am very ready, at any other time, to visit your Reverend Highness, as propriety dictates, and as I ought to observe your pleasure in every other case, provided your Reverend Highness should hint this to me at some other time: For I confess that I ought to comply, not merely with your requests, but rather to perform your commands. From Frauenberg, 1533.

Your Reverend Highness's most devoted,

NICOLAS COPERNICUS.

To the most Reverend Father and Lord in Christ, John, Bishop of Culm, 1533.

ART. XII.—*Account of the Singular Treatment of a Queen Bee.* By Mr GEORGE CRON. Communicated by the Author.

THOSE that take an interest in bees, and know something of their various instincts, are aware, that the love and reverence which they have for the queen, is not a little remarkable. In proof of this, I am enabled to add an uncommon instance, completely new to me, and I doubt not to many of your readers. I shall have to treat the subject with considerable minuteness, in order that the reader may be fitted to judge, whether, in this case, the bees really acted from affection or from hostility,—whether, in short, their intention was to protect or to kill. I cannot help being of opinion that their object was to shield the queen bee from what, in their alarm, they considered as impending destruction; but be this as it may, the fact to be related is a curious one, and deserves to be noticed, as adding to the information already acquired, with respect to the surprising economy of these interesting insects.

Being near the close of the honey season, it was proposed to drive a swarm of bees out of one hive into another, with a view to secure for the winter a good stock-swarm,—a plan which, by the way, is not more merciful than judicious; and there is much room for regret that it is not more generally followed. It happened that the hive out of which the bees were to be driven, consisted of a double swarm, two second casts having united at the time they were thrown, though, of course, there would now be but a single queen bee, as it seems to be generally held, that, in such circumstances, one of the royal personages is sure to perish in mutual conflict.

This hive was gently turned upside down, and the one prepared for the reception of the swarm was placed with care exactly upon it, with a view that the bees might have free access to each, without having it in their power to escape from either. The swarm of the latter was not extremely strong, though the number of bees was thought to be considerable; and there is every reason to believe that the hive had a living queen bee. It is of

consequence to remark this, because it will be found, that the circumstance affects not a little the interest which attaches to the incident, the characters of which we have now to narrate.

It was at an early hour of the afternoon when the hives were placed in close contact; and, after some slight attempts, by knocking the under hive gently with the hand, to expel the swarm from it to the one above, they were permitted thus to remain till next day, in order that the bees might at their leisure ascend during the night. It is very possible, that while the hives were left standing after this manner, the queen bees might happen to exchange places; or, at least, the queen belonging to the hive above might contrive to mingle with the swarm of that below. But though this supposition is not at all a probable one, the possibility of it, at all events, must not be lost sight of, in any deduction that may be drawn from the facts to be noticed in the subsequent narrative.

It was intended next morning to attempt the final expulsion of the swarm from the one hive into the other. With this view, the hive into which the bees were to be driven, and which had stood uppermost during the night, was taken off, and placed upon the stool from which the other had been removed, as it was judged that the bees would very naturally resort to their usual abode. In all likelihood but few bees had gone up, as it was hoped they would, during the night, because, when the combs of the under hive were thus full in view, the swarm was discovered to be in great strength, distinguished in an eminent degree for a lively, active, and healthful appearance. This hive was now taken into both hands, and, with as much severity as the fragility of the combs would permit, was smartly knocked on all sides, with a view to frighten its inmates from their most retired recesses. This mode of procedure, it is evident, caused the utmost consternation; for, though the bees rose in thousands from their cells, not one shewed any disposition to sting, —which they would doubtless have done, had they not been thrown into a sort of trepidation and dismay. But as numbers, unwilling to leave their home, and the fruit of all their labour, were still seen clustering together in several parts of the hive, this kind of agitation was kept up for at least the space of half an hour, a feather being frequently passed between the inter-

stices of the combs, with a view to sweep out, or at any rate to frighten the more reluctant. Whether this be the safest or most speedy way of expelling bees from their hives, I know not; but it seems at all events not a bad method for putting them into extreme terror, for they were now seen running at intervals wildly up and down, evincing, by their awakened gestures and tone of hum, strong symptoms of alarm and disorder. And I mention this, because I am of opinion that it was the occasion of the incident on account of which these circumstances have been recorded.

During the progress of this transaction, it became of course a subject of curiosity to get a sight of the queen bee, and an object of interest and attention to see her make a safe departure. For a long while she could not be at all recognised; but at length, on the swarm being almost all expelled, she was seen to fall from the hive, a bee or two clinging eagerly by her. She fell upon a cloth that was spread upon the ground, and, after running for a little time, with the utmost agility and apparent strength, was taken up into the hand, a single bee still continuing to have a firm hold of one of her legs. This one, however, now quitted its grasp, and, on the queen being immediately put down at the mouth of the hive receiving the swarm, a very singular and interesting spectacle was to be seen. In an instant several bees seized upon her, with a sort of eager violence, that was apparently almost indicative of hostility, only their ultimate aim appeared to be merely to lay a sure hold on her, as they made no attempt to wound, by the use of their stings.

This royal guard increased in a moment to the number of a dozen or fifteen, it being quite impossible any longer to obtain a single glimpse of her majesty, so completely was she encircled in the close embraces of these her obtrusive or affectionate assailants. Those bees that had got the main hold, clung to her with a sort of wild determination; but those that did not consider themselves as having so serious a trust, lay clasped together, with countenances somewhat expressive of satisfaction and contentment, forming a little ball, the centre of which was the queen, that might be tumbled over without causing them to quit their hold, or being productive of any injury.

They seized her with their pincers by the wings mainly, and by the legs, but at times by every part also of the body of which any hold could be taken, such as the rings of her belly, and the several parts of her head, excepting the antennæ, which I do not recollect of noticing. At first, they seemed to be making towards the hive with their royal captive; but on being once prevented, they never after attempted any movement of this kind, though they kept the queen bee in this sort of imprisonment upwards of an hour. It was observable all the while, that the swarm in general wás not affected by this incident, but continued to go by and over the little ball which embraced the queen, without bestowing on it the slightest attention. And so compactly did these few bees adhere to one another, that it was amusing to see strangers, which hopes of plunder, or the unusual commotion, had attracted, entangled frequently in their eager grasp, and now and then running off in great alarm with queen and bees both, dragging after them the little ball with considerable velocity, in one of which adventures, it fell from the mouth of the hive upon the ground, a distance of perhaps a foot and a half, the little resolute creatures nevertheless retaining their hold.

During the exhibition of this curious scene, it was remarked that several of the bees, especially on being much disturbed, let go their hold, but were instantly succeeded by others quite as active and determined. And it was very observable, that when any part of the queen bee could be seen, (a thing which seldom took place), she appeared to be struggling with much eagerness to get free. It was not often, however, that she had liberty enough to move either head, leg, or wing; and as a proof that she was held against her inclination, she was heard at intervals uttering a shrill cry, something after the manner of what is heard before the departure of a second or third swarm, only the tone on this occasion was expressive of constraint rather than of pain.

This remarkable spectacle having continued more than an hour, there was considerable reason to fear, that so much struggling on her part, and so great actual exertion on theirs, would inevitably prove fatal to the queen bee, and thus cause the ruin of the whole swarm. On this account, an attempt was

now made to disentangle the royal captive, but for a long time without effect, till at length being taken into the hand, the bees reluctantly took their departure, leaving the queen bee in a very pitiful plight, sorely harassed and fatigued, and bearing many marks, if not of actual violence, at least of harsh usage. But it is here worthy of remark, that the main end which the bees appeared to have all along in view, was to obtain possession of a firm hold, which they generally took with certainly not a little violence, especially considering that the queen bee was the object on which they were seizing. Their great aim, however, was evidently only to detain, as their manner and gestures were by no means indicative of any intention to kill, since even those that were nearest to the royal person, and held the firmest grasp, were not observed to make any use at all of their stings. But their protracted efforts to detain her, whether the result of hostility or affection, proved fatal to the object of their unusual anxiety, which, on getting disentangled, was seen to walk but very imperfectly, was motionless in the space of half an hour, and died in the course of that evening. One of her fore-legs was maimed to a degree that made it useless; her head was considerably bent down; her wings were much distorted and shattered; and several of the rings of her belly torn on the edge. Her body shewed no clear symptom, however, of her having been stung. And I am persuaded that her death was in consequence of extreme fatigue, occasioned by a struggle of upwards of an hour, against very superior numbers.

It deserves notice, that when taken back almost motionless, and put down again at the mouth of the hive, the bees were no longer seen clustering around her; but one or two made an attempt to carry her off, after the manner they do those whose bodies are found lying dead in the hive.

Now, in looking back on this interesting spectacle, the several circumstances of which it has been judged proper to describe at considerable length, there can hardly, I think, remain any doubt, that the bees acted from violent terror, their sole intention being to protect the queen bee, or prevent her from making her escape, and deserting them in a season in their eyes so perilous. The only objection to this opinion, is the supposition that the queen bee belonging to the other hive had introduced herself

into this swarm, and that it was the object of those in clasping her so eagerly to destroy her. Yet were it certain that this idea is quite accurate, it seems fitted to shew, and that in a very interesting manner, that if common bees do at times put to death the queen bee, the mode of extermination they adopt is altogether distinct from what they pursue in regard to one another. They impetuously seize, it is true, with their feet and pincers on any part apparently of the royal person, clinging firmly to her, but yet in a sort of placid contentment, making not the slightest use of their stings, as the dead body plainly indicated, it being extremely easy for any one familiar with the subject to determine whether bees have perished of such wounds.

But to put a period to these remarks, which can be interesting to those only who pursue with enthusiasm the study of these delightful insects, the entire subject may be resolved into the two following questions: If it was the queen of their own swarm which the bees thus held, what motive can be assigned for their conduct; and why did they detain her for so fatal a length of time? If, on the other hand, it was the queen bee belonging to the other hive, what end in thus acting can it be supposed they had in view; or if their intentions were to destroy, why not despatch her with their stings instantly?

To these questions a careful consideration of the several circumstances noticed in regard to this singular incident, will best afford a satisfactory answer. Fearful, however, lest this paper be already of more than sufficient length, I forbear offering any farther observations, aware that those who are enthusiasts in the study of bees will be extremely glad of these curious facts; and I do not suppose that any but such will with any sort of patience bestow on them the trouble of perusal.

Skaills,
Dumfriesshire,
October 3. 1820.

ART. XIII.—*Account of recent Astronomical Observations made on the Continent.* By M. C. RUMKER, Rector of the Nautical Academy, Hamburgh. In a Letter to Dr BREWSTER

DEAR SIR, LONDON, *26th April* 1821.

I BEG leave to transmit to you some recent astronomical observations, which I trust you will find deserving of notice.

The first series is a very extensive collection of observations of the occultations of the Pleiades by the moon on the 29th August 1820, of which I have calculated the greater part.

The second series are observations which I made at Hamburgh, and to which corresponding ones may be obtained; and the last is an interesting observation of an occultation of Jupiter, observed by Dr Olbers of Bremen, accompanied by a similar one made long ago at Malta. Yours, &c. C. RUMKER.

Collection of Observations of the Occultations of the Pleiades by the Moon, August 29. 1820.

No. 1.

Observations made by Professor Bessel at Königsberg.

	Sidereal Time. Immersion.	Emersion.
δ Merope,	19^h 54′ 7″.8	20^h 41′ 22″.3
p, -	-	21 3 48.8
η Alcyone,	20 26 15.3	21 7 58.2
s, -	- -	21 28 42.5
Piazzi, iii^h 161,	-	21 36 22.4
f Atlas,	20 54 52.5	21 48 21.6
h Pleione,	20 58 44.3	21 51 17.5
Piazzi, iii 164,	-	22 7 3.3

No. 2.

Observations made by Dr Olbers at Bremen.

	Mean Time. Immersion.	Emersion.
p, -	-	9^h 43′ 58″
η, Alcyone,	-	9 48 28
s, -	-	10 13 16
f, Atlas,	9^h 38′ 4″	10 29 18
h, Pleione,	9 42 23	10 31 3.5
		10 42 36

No. 3.

Observations made by Professor Harding at Göttingen.

	Sidereal Time. Immersion.	Emersion.
δ Merope,	-	19^h 58′ 12″.2
p, -	-	20 18 37.2
		20 21 54.2
η Alcyone,	- -	20 22 55.2
s, -	-	20 46 29.2
		20 53 45.2
		20 55 59.2
Atlas,	20^h 12 1″.2	21 3 12.7
Pleione,	20 16 14.4	21 5 11.2

No. 4.

Observations made by Professor Gauss, K. G. Aul. Counc. Göttingen.

	Mean Time. Immersion.	Emersion.
p, -	-	20^h 18′ 36″.5
η, Alcyone,	-	20 22 58.1
Atlas,	20^h 11′ 57.″7	
Pleione.	20 16 5.3	

No. 5.

Professor Schumacher, K. D. observed at Altona, in Lat. 53° 32′ 50″; Long. 39′ 51″. Mean Time.

	Emersion.
Merope, -	9h 29′ 0″.6

No. 6.

C. Rumker, Hamburgh, Lat. 53° 33′ 8″; Long. 39′ 59″. Mean Time.

	Immersion.	Emersion.
Alcyone,	9h 17′ 3″	
Merope, - -		9h 29′ 5″.3

No. 7.

Professor Bode at Berlin.

	Mean Time.
Emersion of Alcyone,	10h 5′ 21″.5

No. 8.

Dr Jänish at Moskwa, Russia, Lat. 55° 14′ 15″; Long. 2° 30′ 42″. Mean Time.

	Immersion.	Emersion.
Merope,	10h 24′ 47″.67	
Alcyone,	10 56 59.6	11h 47′ 58″.6

Perhaps the following occultations which I have observed in Hamburgh, may find corresponding ones.

1820, Sept. 25.	Alcyone,	Immersion,	6h 16′ 28″.61	Sidereal Time.
Nov. 17.	π Piscium,	-	0 10 20.49	
Dec. 14.	π Piscium,	-	4 16 19.5	
16.	* Arietis,	- -	2 35 17.9	
25.	84 Leonis,	- -	8 23 16.1	
—	83 Leonis,	Emersion,	8 44 39.5	
—	Star following,	———	8 46 0.2	
—	84 Leonis,	———	9 27 9.6	
1821, Feb. 7.	*	Immersion,	3 27 56	Copenhagen,
8.		———	5 0 4	7h 58′ 57″.5 Mean Time.
—		———	6 53 44	
9.	-	———	6 1 23.7	

The following observations of the occultations of the Pleiades by the moon, on February 9. 1821, were made by Professor Schumacher at Copenhagen, and by me at Hamburgh:

Feb. 9.—Copenhagen, Lat. 55° 40′ 26″; Long. 50° 20′.

	Mean Time. Immersion.
Anonymous, -	12h 2′ 58″.3
Celæno, - -	12 14 9.3
Taygete, - -	12 23 3.9
Anon. - -	12 27 30.4
Anon. - -	12 34 43.0
Maja, - -	12 36 11.0
Asterope, -	12 48 37.6
Anon. - -	12 50 37.1
Anon. - -	12 57 1.7
Emersion.	
Celæno, - -	13 8 21.7
Feb. 10. Immersion,	9 24 4.8

Hamburgh,—Lat. and Long. as above.

	Sidereal Time.
* -	9h 1′ 30″.8
-	9 4 2.7
Celæno,	9 15 45.8
Taygete,	9 24 34.8
Maja,	9 39 46.1
Asterope,	9 44 24.6
	10 8 0.4
Emersion.	
Maja, -	10 31 52.3
	6 35 22.2

I have the pleasure of communicating to you a very interesting observation of an occultation of Jupiter by the Moon, observed by Dr Olbers at Bremen. The weather was not favourable; the air being so thick, that the immersions and emersions of the satellites of Jupiter could not be observed with distinctness. The belts on Jupiter were however sufficiently clear. Magnifying power 110.

October 18. 1821.—Mean time at Bremen.

Immersion of ♃ preceding limb, -	$5^h\,26'\,14''.2$
Complete immersion, - -	5 29 36.2
Beginning of emersion, - -	51 29.0
Complete emersion, - -	54 38.0

Dr Olbers adds, that the immersion of the preceding limb of Jupiter required particular attention. On account of the spheroidal figure of the obliquely entering planet, it was difficult to observe the moment when the invisible dark limb of the moon made the first impression on it.

I shall here subjoin a similar observation made by M. d'Angos, Knight of Malta, of an occultation of Venus by the Moon, on April 12. 1785, with an achromatic telescope of $3\frac{1}{2}$ feet.

Contact of limbs, - - -	$0^h\,32'\,12'$	Apparent time at Malta.
The lower horn disappears, -	0 32 40	
Venus emerges behind the bright limb of the Moon, - - -	1 56 18	
The lower horn emerges, - -	1 56 48	

In the year 1824, an occultation of Uranus by the Moon will be visible in the East Indies, &c.

ART. XIV.—*Account of a Chinese Mangle.* By ANDREW WADDELL, Esq. F. R. S. E. In a Letter to Dr BREWSTER.

DEAR SIR,

I HAVE the pleasure to send you a drawing and description of a *Chinese Mangle*, the model of which you saw at my house, and which you were inclined to think was worthy of a place in the Edinburgh Philosophical Journal.

I do not recollect any where to have seen a description of it, although it was as far back as the year 1786, that I first saw it

at *Canton* in *China*, when one day walking through the suburbs of that city. On passing the door of a house that was open, and seeing a man moving a large stone on the floor with his feet, I was induced to look in, and observed him at work mangling a piece of blue *nankeen-cloth*, by means of the stone. After having observed his labours for about fifteen minutes or more, I was so much impressed with the great effect produced by very little labour, and the most simple means, that it induced me a few days after to have a model of it made from recollection.

Plate IV. Fig. 1. gives two views of the *mangle:*

And Fig. 1. shows the stone or mangle at rest standing on its end on the floor, with the roller and cloth lying ready to begin work.

A, The floor of the house, which was paved with *tiles*.

B, A concavity in the floor, lined, to appearance, with hard wood.

C, The roller with the cloth on it.

D, The stone, being a hard sandstone in appearance, and in weight from ten to twelve hundred weight, but so very ingeniously formed, as to stand on either end, as the workman chooses to rest it, while he examines his work; and as he steps upon the stone again, he allows it to fall gently down on the roller.

E, E, Two vertical bamboos, (cane,) fixed into the floor, with one across their upper ends, for the man to hold by when at work on the stone.

Fig. 2. Shows the man mounted on the stone, and at work pressing alternately on each foot, by which the stone receives an alternate motion, which makes the roller with the cloth pass over the whole of the concavity in the floor, and with as much or as little velocity as the workman chooses to give it.

Aw. Waddell.

Leith, 30*th April* 1821.

ART. XV.—*Account of a Map constructed by a Native of Taunu, of the country south from Ava.* By FRANCIS HAMILTON, M. D. F. R. S. Lond. & Edin., and F. A. S. L. & E. Communicated by the Author.

THIS Map (See Plate V.) may be considered as a portion or continuation of that published in the seventh Number of the Philosophical Journal, and differs from it in style chiefly, by the compiler having omitted the imitations of trees, which were mentioned to him as rather an encumbrance than an ornament.

In order to judge of the scale which should be assumed for the distances marked days' journies and leagues (dain), we have the following data:

From Rangoun City to Rangounkæn on the Erawadi, we have, days' journies, -	2.0	equal to G. miles	30.
From the latter to Pri, - - -	5.5.		106
From Pasein to Pri, - - -	8.2		108
From Rangoun to Old Aynwa or Ava, -	15.9		295
Days' Journies,	31.6 ;	dain, 316 ; G. miles	539

That is to say, on routes of a considerable distance, the league or dain will give a little less than $1\frac{3}{4}$ geographical miles direct distance, and the day's journey nearly 17 G. miles; so that probably the road distance is not much short of what the distances estimated in the Map will require, that is to say, 22 British miles for each day's journey.

One of the most remarkable features of the country represented in this Map is, that although it is far from level, consisting chiefly of swelling grounds, many of which contain rock; and although in many places these rise even to hills disposed in ridges of considerable length, though of no great elevation, yet the rivers anastomose almost as much as in the low lands of Bengal, where there is not the slightest trace of rock, stone, or eminence. Indeed, near the Erawadi, the principal extent of a delta composed of alluvial mud, like that of the Ganges, reaches only from Rangoum to the mountains of Modæn or Negrais; for the great temples of Shue Modo at Rangoum and of Kiaikkho at Sanliæn, (Sirian,) are on rocky eminences about 110 G. miles from the western mountains. The base of the

triangle or delta will thus be of this extent, while its apex, a little above Hænsada, may be considered as not quite 130 G. miles from the sea. It is true, that near the mouths of the Zittaun and Saluæn, and near also the creeks communicating between these and the Erawadi, there is some alluvial muddy soil, and I saw some between Sanliæn and the ancient capital of Pago or Pegu; but the extent, I imagine, is inconsiderable, as Pago has near it eminences containing stone, and hills come close to the sea at Mouttama, (Martaban,) on the mouth of the Saluæn. Although, therefore, the Erawadi equals at least the Ganges, and although the Saluæn is a large river, not indeed to be compared with the Brahmaputra, the alluvial territory of Pegu is by no means to be compared in extent with Bengal, because the latter, besides the two great rivers at the extremities, receives the Gagra, Gandaki, Kosi, and Tista, all of great magnitude, while only the extreme rivers of Pegu spring from alpine snows. The anastomosing branches of the Pegu rivers, beyond the reach of the tide, are chiefly swelled by the periodical rains, and many of them, for a great portion of the year, are nearly dry; but for a time they are of much use, both as fertilizing the country and for commerce, as during floods they admit of extensive navigation. They also contribute much to the health of the climate, by carrying off superfluous water, and preventing it from corrupting the air; so that Rangoun, surrounded by inosculating rivers, enjoys a salubrious air, very unlike Calcutta, Dakha, or the intermediate places, which are still more unhealthy.

In the accompanying Map, as well as in the General Map of the slave, (See this Journal, Vol. II. Plate X.,) the branches of the river west from the main channel of the Erawadi, the chief of which is called Anaukkiaun, have been entirely omitted, as being placed in a remote and obscure corner; but the inosculating branches between the Erawadi, called, near its mouth, Alægiaun, and the Saluæn, have, in the accompanying map, been detailed with great care, and their existence is confirmed by another map of the Pegu country, drawn by the slave, although in the general map he omitted them, as of comparative little importance, preserving only the Paunlaun or Zittaun river, which rises from

a common source with the Panlaun, and this running to Ava, commences the anastomosis or plexus of rivers, to use another anatomical phrase, not inapplicable to the present subject.

The lake, the common source of the Panlaun and Paunlaun rivers, in the accompanying map, as well as in the general map of the slave, is situated SE. from Amarapura, and this is the real course of the Panlaun, which, in the map of the parts north from Ava, in order to find room for the places in its vicinity, was turned to the east. Gnaunrué, a town on the banks of this lake, is six days' journey from Amarapura, which may give a direct distance of about 102 G. miles, placing the lake nearly about where it stands in Arrowsmith's map of Asia.

The Paunlaun, which runs south a little westerly from this lake, is by far larger than the Panlaun. It proceeds about SSW. to Taunu, distant about 100 G. miles in a direct line; for, although the distance is not mentioned in this map, Taunu being $6\frac{3}{10}$ days' journey from Rangoun, 5 days from Prin or Prome, and $9\frac{6}{10}$ from Ava, it probably is a few miles farther to the SSW. than the map of Asia places it, under the name of Tongho. From thence the Paunlaun turns a little eastward of south, until it reaches Zittaun, where, according to this map, it takes the name of the Zittaun River; but, in the general map, such a change of name is not noticed. Below Zittaun this river forms an estuary of considerable size.

From the same lake, in the rainy season at least, a third river proceeds to the SE., connecting thus the Saluæn with the Erawadi plexus of rivers, as I have called it.

On the west this map extends to the mountains occupied by the Karæn and Khiæn, and which separate the countries of the Mranmas and Jos from that of the Rakhain. We are not to conceive, that, in this mountainous space, there is any thing like a triple ridge extending north from Cape Negrais, the Modæn of the Mranmas, as represented in the general map. The whole region is mountainous, with valleys winding in all directions; but, as travellers, in traversing different parts, will probably be under the necessity of passing over nearly an equal number of hills, it is natural enough for this number to be noticed, and to give rise to the supposition of distinct ridges. There is no doubt, however, that there is a separate ridge

bounding the Jo valley on the east; but that does not enter in this map, which begins south from Paghan, where this ridge commences.

The mountains of the Karæn and Khiæn, as represented in this map, approach very near the Erawadi from the southern boundary of the Mranma country, until they reach Renanghiaun, about 115 miles in a direct line above Prin, when they bend a little to the west, and the Erawadi at the same time inclining much to the east, a large space is left between for the Jo country, and for the Mranma peninsula, confined between the Khiænduæn and the Erawadi; but there is no reason that I know of to suppose that these mountains bend so much to the west, as Mr Arrowsmith supposes: And I have little doubt that their centre extends perhaps about N. by W., separating Kasi or Meckely from Akobat or Cachar, until they reach the frontier of Asam, the river Surma of Bengal probably rising from their northern end.

It is to this map chiefly, that I can refer for the detail of the Mranma territory, between the foregoing mentioned mountains on the west, to the Erawadi on the east, and from the mouth of the Khiænduæn on the north, to the frontier of the Talain country on the south. Now, this frontier is immediately north from Regaen, a customhouse near the city called Sarawadi or Mængri. The customhouse has been laid down by Mr Wood, under the name Yeagain, 30 G. miles in a direct line below Prin (Prome W.): and, the frontier being about one-third of the distance nearer Prin, we shall have the proper territory of the Mranmas, extending in a direct line about 190 G. miles along the Erawadi to the junction of the Khiænduæn, and then extending along the latter, according to the map of the country north from Ava, about 78 G. miles, giving thus about 268 G. miles for its total length from north to south, along its western side. Along its eastern frontier, it extends from a little north from Zabbænago, on the Erawadi, to the water-course called Ruanuæ, 21 or 22 G. miles south from Taunu, which will give a direct distance of nearly 290 G. miles. The average breadth from east to west may be about 100 G. miles, so that the proper country of the Mranmas may contain from 27,000 to 28,000

square G. miles, or between 36,000 and 37,000 B. miles, or rather more than Ireland.

Besides the places, the situations of which have been ascertained by Mr Wood's survey, the most important geographical station in this part of the country is Taunu. According to this map, one of our best authorities, the whole distance between Rangoun and Old Ava is 156 leagues (dain), and of these, the distance between Rangoun and Tanu, being 63, we may calculate this to be $\frac{63}{139}$ of 260 G. miles, the total direct distance in the map of Asia between Rangoun and Ava. By this we shall have Taunu 116 G. miles from Rangoun, and it is five days' journey, or 85 G. miles, from Prin. According to this, Taunu should lie in about 13° 15′ N. Lat. and 96° 43′ Long. East from Greenwich, very near where Mr Arrowsmith has placed it. This being a most important station, I shall here consider its situation from another authority. According to this, the whole distance between Rangoun and Amarapura, being 170 leagues or dain, 100 of these are between Amarapura and Taunu. Now, the former distance being 316 G. miles, the latter will be 186 G. miles, coinciding exactly with the map of Asia, which I therefore think must be nearly right; and the compiler of the Universal History, most justly, therefore, suspected Pinto of exaggeration, when he stated it to be 160 leagues from Pegu.

Although in the Universal History we read frequently of the Kingdom of Taunu, (or Tangu as it is there called,) and of its kings, who governed in the end of the 16th and beginning of the 17th centuries of the Christian era, there is no reason to suppose but that it was always a part of the Mranma territory, and its Princes mere vicegerents of the Mranma Sovereigns, whether these resided at Ava or Pegu. The Portuguese have, indeed, been in the habit of bestowing the title of King on even the Mrowuns or Governors of the Provinces, retained for the immediate support of the King's own expense, or his proper domain, such as Pegu was when I was in the country; and they would have been still more justifiable in giving the title of King to any prince of the royal family, who might hold as an appanage, for his support, a province such as Taunu, although the Sovereign retained complete authority in every matter, allotting merely the revenue to the prince for his support. Such was the state in

which we found Taunu in the year 1795, it being then held as an appanage by the King's second son. The ancient city of Taunu, however, stood at some distance, called three dain, from the present city, which was built by the king reigning in 1795, adjacent to the Paunlaun, while the old city stood at the junction of the Pabæh with the Khabaun.

The King of Prom, mentioned in the Universal History, (vi. 74.) seems, like the King of Taunu, to have been merely a Mranma chief, who had received the revenues of a province for his subsistence. Prom, called usually Prin by the Mranmas, and Peeaye by Mr Wood, in the map of Asia, appears as Pecaye. The present city, where the fourth in rank of the King's sons resided in 1795, is situated close on the Erawadi; but the old capital of this province was at some distance from the river, and was called Rase in the vulgar, and Sæhrekattara in the sacred language. From what language the word Prom or Prome is derived I cannot say; it may, perhaps, be the mere production of some typographical error, like the Pecaye of Mr Arrowsmith; and many instances occur of European geographers adhering to such errors with great pertinacity. The word Prin, in some of the maps which I have, is written Pri, and in others Pre, to be pronounced Pyee or Pyé, no doubt the same with the Peeaye of Mr Wood.

To proceed south into the territory of the Talain, the Pasein of the Mranmas is the Persaim or Basseen of Europeans, and in 1795 was the appanage of the King's fifth son. In this map it is represented to have then stood much nearer the sea, and the great channel of the Erawadi coming from Rangoun customhouse, than it did, when the English had at the place a factory, in which state the authorities followed by Mr Arrowsmith represent the vicinity. It must, indeed, be observed, that in a country, where the houses consist of sticks, bamboos and mats, the towns become almost as moveable as camps, and are very frequently changing. Yet the town of Pasein still, no doubt, is much nearer the Anaukkiaun, or western branch of the Erawadi, than to the Alægiaun, or middle branch, though the contrary is represented in some of the native maps. In the one now under discussion, the total omission of the western branch deprives us of its authority.

Samrændaun is probably the town now occupied by the descendants of those who dwelt at the place called Kosmi, in the Universal History, (p. 41.); but it probably does not occupy the same place; just as the Dala of this map, opposite to Rangoun, is not the ancient town so called, which stood on the Panlain river, in our charts called China Bakkar; but the governor of the district, which in 1795 was the appanage of Mibia bhura, the favourite queen's mother, having taken up his residence at Maindu, nearly opposite to Rangoun, this place is now usually called Dala.

Rangoun, the present great emporium of the empire, was built by Alaun-bhura, the first prince of the reigning dynasty, after his conquest of Pegu. It is most conveniently situated in a very healthy and fertile country, near the former town of Tagoun, the Dogon or Dagon of the Universal History, (p. 41. 46.) long celebrated for a great temple of Gautama, which stands on an eminence about two miles from the town.

The Sirian of the Universal History (p. 45.) is the Sanliæn of this map. The ancient city of Pegu, as it is called in the Universal History, (p. 43.) is the Pago of the vulgar dialect of the Mranmas, while in their sacred language it is called Hansawati. Why Mr Arrowsmith has placed it so far from Rangoun (50 G. miles in a direct line) I cannot say, as all authorities agree in placing it but a little northward of east from thence, and at the distance of either one or two days journey. In fact, I went to it from Rangoun with two floods, and I reckon that neither lasted above four hours, which at five miles an hour would only give a total distance of 40 G. miles, and as the river winds exceedingly, and proceeds first nearly east, and then nearly north, I doubt much of the direct distance exceeding 20 or 30 miles, which is usually gone by water in 24 hours or two tides, and no doubt may be easily travelled in one day by land. It must be observed, that, although the tide rises strong for some way above Pago, the river passing this city is a mere anastomosing branch of the Paunlaun or Zittaun, connecting that with the Erawadi, but having little depth of water; and that most of what is said of this river in the Universal History (p. 40.), is only applicable to the Saluæn, which, rising on the west side of

Yunnan, passes the borders of Jangoma (Saenmæ), and then enters the kingdom of Pago; but it neither passes near the capital city, nor does it fall into the sea below it; for it passes Mouttama far to the eastward.

The Zayton of the Universal History (p. 49.), from whence Conti put to sea in the year 1430, is probably the Zittaun of this map, a city on the estuary of the Paunlaun, called often, as in this map, the river of Zittaun, from the city on its banks, which we may consider as about 10 G. miles direct distance east from Pago. Although, as I have said, this latter city stands on the east side of a small branch of the same river, the two branches, towards the south, again communicate by a channel, which is in general dry, but which, during the periodical rains, becomes navigable. Boats can at all times pass up from the sea to Zittaun; but it is only in floods that they can proceed thence to Taunu.

In the Universal History (l. c.), it is supposed that Zayton is the same with Satan or Zatan, to which the Siammese advanced in the year 1533, and this may be the case; but Satan may as well be the Satoun of this map, a town, according to this authority, placed two days journey east from Zittaun, on a small channel called the Taunwæh or Tounwain. Lower down on this channel, which seems to enter the sea at the mouth of what Europeans call Martaban Bay, this map places a celebrated temple called Zaingiaik, three days journey from Satoun.

From Zaingiaik to Mouttama, or, as we call it, Martaban (Universal History p. 43.), are in this map two days journey, the city standing a considerable way up the Saluæn River, and not on the side of the bay, as represented in our maps. No doubt the worst of our sea charts are in general preferable to the map here published; but, owing to the extraordinary violence of the tides, and to the danger of being so far embayed, European vessels have very seldom visited this important place, and I suspect that it is really situated a considerable way up the river, while the customhouse at the mouth of this is what has been laid down in our maps, being the place frequented by seafaring visitors. The distance given in this map from Rangoun to Mouttama is no less than nine days journey, which, in proportion to the other distances in the map, would give a direct

distance of 153 G. miles.
circuitous, as it first procee
south to Zaingiaik, and fi
to Mouttama, while, owing
day's journey may here be
north from Ava. In the p
gives twelve days' journey
distance in the map of Asia
journey. Even at this rate
from Rangoun. I am, the
ror has here crept into Arr
Martaban only 80 G. miles

The city called Je, is no
tuated on the island, at the
Arrowsmith's map of Asia
cannot account. In many
Island, probably from the
for the bay was chiefly freq
The Mranma name of the
dependency on the governm
the district is not situated
considerably farther south.
the island by the compiler,
rection.

The detail of the countr
this map is not great, and
settles is the situation of Ju
note in this territory. It is
Taunu, and five and a half
fore mentioned, the latter to
former, and this latter dist
for, although Mouttama is
placed in the map of Asia,
its distance from Taunu.
Mouttama to stand right in
Junzalæn in about 17° 20′
Greenwich, considerably w
ing to the map of Asia, in

Mæpræn, or river of Siam, is brought too far to the west, thus encroaching considerably on the territory of the Mrelap Shan.

ART. XVI.—*Observations on the Natural History and Structure of the Proteus Anguinus.* By Prof. CONFIGLIACHI and Dr RUSCONI. (Continued from Vol. IV. p. 406.)

HAVING, in the former communication, detailed the leading circumstances in the natural history of the Proteus, I proceed now to exhibit a sketch of the anatomy of this animal, more particularly of its circulating and respiratory organs.

1. *Of the Skeleton.*

The authors commence their anatomical description of the Proteus, by treating first of the skeleton. The pieces which compose it, they observe, differ not only as to form, but also in regard to flexibility and hardness. Some parts are membranous, others cartilaginous, others between cartilage and bone, and others are entirely osseous. With respect to natural hardness, the inferior maxilla, and the arches which support the gills and form the branchial apertures, come first; next, the vertebræ; then the cranium; afterwards, the four extremities; and finally, the pelvis and scapula, and the two pieces which concur with the latter to form the articulation of the shoulder. The rigidity of the bones will doubtless encrease with age; but the authors cannot pronounce on the actual age of any of the animals they dissected, nor assert with confidence if they had arrived at their greatest size. In several, however, the organs of generation were perfectly developed; and one that was dissected, and which had been previously kept alive, in their possession, for ten months, did not appear to have increased an atom in size; nor were the bones different, in any respect, from those of other protei. In general, however, they regard the bones of the proteus as more tender than those of the aquatic salamander.

In the *cranium* of these animals there is no temporal fossa, nor zygomatic process, nor orbit to be seen; and the bones

themselves are so thin that the entire mass of brain is sometimes visible through them. The *temporal* bones send processes forward, which articulate with the lower jaw. The two *frontal* bones are long, and lie nearly in the same plane with the *infra* maxillary; but the cranium is a little depressed, in that part formed by the *parietal* bones. Both jaws are furnished with teeth, which are arranged in a beautifully symmetrical order along their respective borders. These teeth have a conical figure. In the upper jaw, their number is about 60; in the lower jaw there are 70, disposed in two rows parallel to one another. The lower jaw is horizontal, and has no ascending process where it articulates with the temporal bone.

The *os hyoides* in the proteus is short: its anterior branches extend backwards and outwards, and then bending upwards, proceed to be attached by a large tendon to the sides of the cranium, behind the articulation of the lower jaw *. The small arches which sustain the gills are three on each side; the first, or exterior one, is the largest; it is connected anteriorly with the posterior extremity of the os hyoides, by the intermedium of a little bone: the second, or middle arch, is also furnished with an intermediate bone, which is attached to the intermediate bone of the first arch: the third, or interior arch, has no intermediate bone, but is connected directly with the second by means of a cartilage. The relative size and position of all these parts may be seen in Plate VI. Fig. 1, where the bones of the head, viewed from below, are represented eight times greater than natural.

From the occiput to the extreme point of the tail there are 59 vertebræ, all of which, except the last, have an osseous structure. Of these, 29 belong to the neck and back, 3 to the sacrum, and 27 to the tail. The first vertebra, or atlas,

* In the Plates, the animal is exhibited in a reversed position, but in the anatomical descriptions, is supposed to be placed on his four feet; hence the terms anterior, or forward, look towards the head; posterior, or backward, towards the tail; superior, or upward, to the back; and inferior, or downward, towards the belly of the animal. The terms interior and exterior are used to denote relative nearness to, or distance, from the median line; and those of internal and external refer simply to the inside or outside of the animal.

has a peculiar form, possessing a dentiform process and articulating surfaces, on which the condyles of the occiput rest. All the others consist of a body, contracted in the middle like an hour-glass, and, except towards the extremity of the tail, each vertebra is furnished with four *articulating apophyses,* or processes, two anterior, and two posterior. The two anterior processes of each vertebra are covered by the posterior ones of the vertebra above it; and its two posterior ones cover, in turn, the anterior processes of the vertebra below: so that, viewed from above, the vertebræ seem to be placed in the manner of tiles.

Beside these processes, all the vertebræ, except the atlas and some of the *caudal,* have two *transverse* processes, which vary a little in form in different parts of the spine. In the third vertebra, these processes, which in the bone above were entire, separate into two portions of unequal length, and to the shorter portion is attached the rudiment of a rib. The same structure is continued downward to the ninth vertebra, where this partition of the process ceases. Below the ninth vertebra, these transverse processes are formed of two thin laminæ united together, and stand out from the body of the bone, like the unfledged wings of a young bird. Gradually these laminæ diminish and disappear, so that about the third or fourth caudal vertebra they exhibit only a simple spine; and this spine, continually becoming smaller, vanishes also about the tenth caudal vertebra. In addition to these transverse processes, the vertebræ of these animals have also their *spinous* processes, which spring from the extreme posterior and superior border of each vertebra. Beside having the dorsal spinous processes, the caudal vertebræ are furnished with two other spinous processes on the opposite surface of the bone, and which, from their position, may be named *ventral.* These spring from the roots of the transverse processes on each side, and proceeding in a parallel course, very soon unite, and form a canal, through which the bloodvessels, that are distributed to the tail, are continued. By the gradual diminution of the processes, this canal is lost before reaching the extremity of the tail.

So much for the bones of the cranium and spine. Of the skeleton there still remain the bones of the four extremities, the pelvis, and the shoulder. But it would be tiresome and useless,

say the authors, to give minute demonstrations of these; their figure, size, and position, are delineated of their natural size in Plate VI. Fig. 2, in which also the bones previously described are exhibited.

The authors having previously remarked that the bones of the proteus are less rigid than those of the aquatic salamander, proceed next to point out a few differences of form in the skeletons of these two animals. At first they appear very similar, but many points of dissimilarity occur on closer inspection. Thus, the transverse processes of the vertebræ in the two animals differ in relative size and form, as do also the costulæ or riblets that spring from them. In the salamander, the cartilages of the shoulder are large enough to extend over the breast, and perform the office of a sternum: in the proteus, on the contrary, they do not touch. Again, the pelvis, in the proteus, is attached by one extremity to the transverse processes of the thirty-first vertebra, and with the other end contributes, with the os pubis, to form the cotyloid cavity: in the salamander, the ileum is not immediately attached to the spine, but only by the intermedium of a little bone: and hence, in these reptiles, the whole pelvis is moveable. In the salamander again, there are only two vertebræ which form the sacrum; in the proteus there are three. Other differences might be noted in the bones of the tail and paws; but not to go into farther details of this sort, the authors prefer giving the results of their observations on the respective locomotive powers of these animals.

2. *Of the Movements of the Proteus in Water and on Land, compared with those of other Animals.*

Whoever shall attend to the particular structure of the vertebræ in the proteus, and their reciprocal connection, will easily perceive that the lateral movements of the head towards the trunk, and the lateral bendings of the trunk itself, will be somewhat limited in its superior part, where the articular apophyses form two planes inclined and converging in one and the same line: but as these processes gradually diminish in size, the capacity of moving laterally will be greater as we descend, and greatest of all when it reaches towards the eighth caudal vertebra, since there the processes entirely disappear. In the sala-

mander, the lateral movements of the trunk will be still more limited than in the proteus, by reason that the ridge, formed by the canal of the spinal cord, will impede the free motion of the articular processes on one another. We have observed attentively, continue the authors, and compared the movements and mode of progression of the proteus, and of the salamander and its larva, both in water and out of it; and have had the satisfaction of seeing that these movements, as well in swimming as in walking, correspond with the consequences previously deduced from a simple examination of the skeleton. A few of these observations they then proceed to relate.

The protei which, with this view, they submitted to observation, had already lived many months in earthen vessels, the bottoms of which were flat and of the figure of a parallelogram. To these vessels were adapted lids formed of many pieces; but so fitted together that the light was unable to penetrate, and the animals consequently lived always in complete darkness. When it became necessary to change the water, a portion of the lid was removed, and then the animal, by moving to the opposite side of the vessel, was able to continue in obscurity.

It has been already observed, that the proteus, in ordinary circumstances, remains as if immoveable at the bottom of the vessel; but at once begins to move with more or less rapidity as the light is let in upon him. Of this fact, the authors availed themselves in their observations on the movements of these animals. Having first discovered in what part of the vessel the animal reposed, the piece of lid above him was gently raised, so as to expose him to light. As soon as he felt its influence, he instantly began to move and withdraw himself to that part of the vessel which was still dark. In making this movement, however, he did not always employ the same kind of motion. Sometimes he drew up the lower part of the trunk and the tail, or rather gathered himself up in the manner of a serpent. In doing this, he made use only of the muscles of the spine, and not of those of the hind limbs, which, during this action, remained quite at ease, and followed the trunk as if they had been paralytic. When the body was thus gathered up, and formed into a serpentine line, the animal thrust the hind limbs to the bottom of the vessel; then stretching forward the whole trunk,

he began, at the same time, to move, one after another, the fore-limbs; so that, making use of the hind limbs as serpents use the ventral scales, and employing the fore-limbs to sustain the head and chest, the animal proceeded slowly along, crawling in part, and in part moving like a biped animal.

Sometimes, again, the proteus sought to avoid the light by making use only of the limbs, keeping then the body and tail in a right line, and moving the limbs alternately as quadrupeds do when they move by steps. At other times, he moved in a way both singular and amusing; for gliding along so as to graze the bottom of the vessel, and supporting himself on the fore-limbs, he kept the hind ones applied to the sides of the trunk; so that the body, from the shoulders backward, was entirely suspended and gliding; and from the shoulders forward, was sustained on the fore-limbs, which moved alternately, and with much quickness, along the bottom of the vessel. This mode of progression was a mixture of the gliding of fishes and the walking of biped animals. A fourth mode in which the animal sought escape from the light was by suddenly betaking himself to swimming. This always occurred when the whole vessel was at once uncovered. At the same time, he glided rapidly over the sides of the vessel, and made attempts to escape out of the water, in order to withdraw himself from the light, which so greatly distressed him. Whilst the proteus thus glides along the sides of the vessel, his motions resemble those of the lamprey, and, like that fish, he drops to the bottom as soon as he ceases to move. The lamprey, however, aids his motions by the incurvations of the trunk, while the proteus glides along chiefly by the use of the tail, which moves to either side with great facility and quickness, exactly as occurs to fishes. This difference arises from the spine of the lamprey being wholly cartilaginous, and therefore equally flexible in every part; but in the proteus, the spine is entirely osseous, and incapable of any considerable degree of flexion, except towards the tail.

Beside the resemblance above noticed in the motions of the lamprey and proteus, it is observed that the latter animal, when he swims, makes no use of the feet, either to start him in the first movement, nor afterwards to sustain his equilibrium. His limbs continue applied always to the sides of the trunk, and may

be compared to the four oars of a boat, floating freely in the water, but attached by leathern loops to the sides: if in this state the boat be urged forward by the winds, the oars are soon forced back by the water and laid alongside the vessel. From not making use of their limbs in thus gliding through the water, it sometimes happens, that these animals, in the act of changing their direction, roll over, and afterwards *right* themselves, as soon as they have got on their new course. The same thing occurs to lampreys, which, in gliding along, sometimes roll over: and when they descend to the bottom, if they wish to remain at rest, and preserve a rectilinear position, they are constrained to attach themselves to some solid substance, by making use of their mouth, which adheres on the principle of suction, else, having neither feet nor fins to maintain themselves straight, they are obliged to lie down on their sides. These facts seem to shew that the principal use of the fins in fishes is to maintain the body *in equilibrio*, as the learned M. Cuvier has observed.

With respect to the movements of the adult salamander in water, as compared with those of the proteus, the authors observe that he is less agile. This may arise from various causes, but principally from the form of the tail, which is not only of less size, but is less adapted for swimming. The larvæ also of the salamander are less agile than the proteus, but in that state they swim with more facility than afterwards. This probably arises from the tail in the larva state being proportionally larger, and also from the larva possessing a lower specific gravity than the adult animal, except when the latter has recently emerged from his winter torpor. That the larvæ have a lower specific gravity than the adult salamanders, is inferred from the fact that they are able to sustain themselves in water, at whatever height they please, only by moving, from time to time, in a slight degree, their claws and tail. It is beautiful to see them continue thus suspended, and as if balanced, on their four limbs in the water, like a bird librating in the air: and afterwards, by striking the water behind them, and by a slight movement of the tail, transfer themselves from one place to another.

The authors subjoin a few remarks on the movements of these several animals on land. Salamanders move from place to place only by a simple motion of the limbs. They have neither the

ventral scales, nor the long ribs of the serpent, which are considered to serve as organs of locomotion. Their trunk stands supported on the four limbs, and does not touch the ground but occasionally, and then only when they move by steps; so that they move on land with the gait common to all quadrupeds. As the larva approaches the period of transformation, his movements resemble those of the adult salamander; but when young, the limbs are so slender and weak, as to be unable to sustain the trunk. At a later period, when taken out of the water, he is able to move a little to the right and left with the anterior part of the body; but with the posterior part, he remains as if fixed to the surface on which he stands.

Not dissimilar to the larvæ above mentioned are the protei, with regard to the capacity of progression out of water. They possess not the incurvations of the trunk, by which they would be enabled to crawl; nor do their four limbs serve them for creeping, nor for moving like quadrupeds. If they bend to the right or left, the entire body forms but a single curve; and on resuming a straight line, the body is found always in the same place. It is true, that, sometimes by pushing with the hind-limbs forcibly against the ground, and stretching forward the trunk, they are able to move a little in advance; but this is done with the greatest difficulty, from the circumstance that their body being smeared with a viscid mucus, adheres to the surface on which they attempt to move.

It thus appears, that, in water, the proteus has the singular and surprising faculty of moving himself in the manner of quadrupeds, of serpents and of fishes; and that he adopts now one kind of movement and now another, according as his necessities urge him to move with greater or less rapidity. His whole structure seems to destine him to live continually in water, and unfits him for the life of a land animal; but the aquatic salamander has limbs sufficiently strong to move on land; and the authors have been assured by men who are employed in fishing in the streams they inhabit, that at certain seasons they go on land.

We find no particular account of the muscular system, but the authors proceed next to treat,

3. *Of the Organs of Digestion.*

The *tongue* of the Proteus through its greater part, is fleshy, and is free both at its apex and on its edges; it is supported, as usual, by the os hyoides. The passage from the *fauces* to the stomach is very short; nor is it easy to fix the place where the *œsophagus* terminates. The *stomach* proceeds in a strait line, is only a little larger than the intestines; and, on a first view, appears like a portion of them. The membrane that covers the fauces, is continued into the stomach and intestines, forming various *rugæ* or longitudinal plaits, more than six or seven in number. These plaits begin where the œsophagus commences; they gradually disappear towards the middle of the stomach, and become again conspicuous as they approach the pylorus, where they are more raised than in any other part of the canal.

The *intestines* are enveloped in a duplicature of peritonæum, which is continued through their whole length. They are formed of very fine and transparent tunics, and make several convolutions in their course. Their size is nearly uniform throughout. In protei recently taken in summer, they always contained fœces; but in winter, neither the stomach nor intestines contained any remnants of food. The internal organs of generation in the male and female, as well as the kidneys, open into the intestines, near the anus.

The *liver* begins and terminates in a point; it is so long, that it extends through two-thirds of the abdomen. In its left margin there are some fissures; and in one deeper than the rest the gall-bladder is lodged. The colour of this viscus is reddish, approaching to that of rust of iron; and its surface is every where speckled with small blackish spots. Its figure is convex below, and concave above towards the spine.

The *spleen* is a finger's breadth in length, and is placed by the side of the stomach, to which it is attached by *vasa brevia* and a doubling of the peritoneum.

The *pancreas* is only half the length of the spleen; and is attached to that portion of the alimentary canal which is immediately below the stomach, and called *duodenum*.

On the whole, the organs of digestion, as well primary as secondary, much resemble those of the aquatic salamander. In these last, however, the stomach is somewhat curved, and placed

a little transversely; and the intestines are evidently divisible into large and small, and are, moreover, furnished with fatty appendages. A general idea of the relative size and position of these several viscera, is exhibited in Plate VII. Fig. 1.

4. *Of certain Opinions of MM. Schreibers and Cuvier, regarding the length and figure of the Alimentary Canal.*

Before quitting these organs, it is proper to notice a difference of opinion between MM. Schreibers and Cuvier, with respect to the length and figure of the alimentary canal. The former exhibits figures, from which we learn that the intestines, before they open externally, make several convolutions; the latter, on the contrary, affirms, that the alimentary canal proceeds almost in a straight line from the mouth to the anus. A simple statement of the appearances exhibited by the several protei examined by the authors, and their observations thereon, will account for this disparity of opinion, and explain its cause.

The three first protei they dissected, had been preserved about seven months in ardent spirits, (brandy,) and in all the three the intestines were convoluted. They then killed and injected a living proteus, and immediately afterwards opened the abdomen, and found the intestines, as in the former examples, to possess a convoluted form. The following summer they received eight other protei, five of which had died on the journey, and were put into spirits, and the three others arrived in a very lively condition. They proceeded at once to anatomise the five dead ones; and found in all of them the intestinal canal almost strait, as described by Cuvier. Perplexed by these opposite appearances, they formed several conjectures as to their cause; but these afforded little satisfaction to the mind, when, in the midst of their doubts, accident at length enabled them to discover the truth. In the succeeding autumn, they obtained a fresh supply of living protei, similar in all respects to those which had arrived in May. One of these was killed and injected; and afterwards, on opening the abdomen, the intestines appeared convoluted, and similar in length to those of the protei *first* examined. These facts being observed and recorded, the animal was put into spirits for a second examination at a future

period. In six or seven days, he was taken out of the spirits to examine the injected vessels; when casting their eyes on the intestines, the authors observed, not without surprise, that the alimentary canal, which, a few days before, was convoluted, soft and transparent, had now become not only opake, but so much shortened, that had they wished to describe it, they might have said in the language of Cuvier, "*qu'il alloit presque en ligne droite d'un bout à l'autre.*" This fact, though at first it excited surprise, brought with it much satisfaction, since it was easy to comprehend, that the shortening of the alimentary canal was owing to the animal having been placed in ardent spirits, while the intestines yet retained their irritability. Of this opinion they afterwards obtained proofs in various ways; and, in particular, having, on one occasion, opened the abdomen of a living proteus for another purpose, they observed the intestines to be at first convoluted and transparent; but under exposure to the air, these organs gradually contracted to such a degree, that, at last, under the eye, they became knotty and opake, and continued to wrinkle and shorten more and more; so that, after the death of the animal, (which occurred in about half an hour,) they were brought nearly to a strait line. Instead of spirits, the animal, in this its dissected state, was placed in water. On visiting it the next day, the alimentary canal was found so much relaxed, as to have recovered its former length; and when the animal, now destitute of irritability, was placed in spirits, its intestines maintained their convoluted form, and did not visibly shorten afterwards but a very few lines. From these and other facts, the authors infer with confidence, that the alimentary canal of the proteus is always naturally convoluted; and that when it is seen to proceed in a strait line, it has suffered contraction from the action of ardent spirits, or some other agent upon it, while still possessed of irritability.

Experiments similar to the foregoing were tried on the intestines of the salamander and frog. These animals resist death longer than the proteus, and may be considered to possess greater irritability; but in them the contraction of the intestines was not observed to equal, in any degree, that of the proteus, arising, probably, from some difference of structure. These obser-

vations, say the authors, not only illustrate certain facts regarding the proteus, but may apologise for those learned writers, who, from not having had the opportuntity of dissecting this animal when recently dead, have deviated, in their anatomical descriptions, some little from the truth.

5. *Of the Organs of Circulation.*

The heart of the proteus is lodged in that triangular space which is formed by the branchial arches. Its situation and size may be seen in Plate VII. Fig. 1. Its structure is simple, consisting, like that of the frog, of one auricle and one ventricle. In figure, also, it resembles the heart of the frog, but is somewhat smaller in proportion. Its auricle is placed forward, and over the ventricle; is slightly toothed on its margins; and to the eye seems as large as the ventricle itself.

From the base of the heart on the right side, springs a very short canal, which proceeds straight forward; but before it gets beyond the auricle, by which it is covered, it expands into a bulbous form. This short canal, the only one that goes out from the heart, is of a soft fibrous texture, similar to that of the heart itself. The bulbous part, on the contrary, possesses great strength, and is opake and tendinous. Hence it is, that whether it be empty or full of blood, it exhibits always a whitish pearly colour, different entirely from the other parts of the vessels, which, when full of blood, appear of a reddish or russet hue.

From this bulb proceed two large arteries, which, almost immediately on quitting it, separate from each other, and are directed, on either side, towards the branchial arches. These two arteries, for greater clearness and convenience of description, are called the two *primary* trunks; but the authors will speak only of one, since what is said of one will apply equally to the other.

The *primary* trunk, then, of the right side, very soon after quitting its fellow, gives off a branch which runs under the first arch through its whole length, where it sends off two arteries, one to the first gill, and the other to the muscles of the os hyoides; afterwards, abandoning the arch, and turning upward and inward, it goes to the roof of the occiput. This *first* branch from the

primary trunk, beside its office of conveying blood to the gills, corresponds, in other respects, to the common carotid.

The other or *second* branch of the primary trunk, is conducted beneath the second or middle arch; and having reached the place where the third arch joins with the second, it sends off an artery which runs along the margin of the third arch, and goes to form the *third* gill. The main portion of this second branch then proceeds along the middle arch; and a little before reaching its posterior extremity, sends another artery for the formation of the *middle* gill. After this, turning upward and inward, it goes for a short way towards the occiput; and getting near the second vertebra, it bends backward and downward by the side of the spine; towards the fourth vertebra, it meets, under the spine, with its fellow from the opposite side, and both then uniting, form together the *aorta descendens*, which is continued towards the tail. It is not necessary to follow the aorta through all the branches it gives off in its descent. We must not, however, omit to mention, that this second or chief branch of the *primary* trunk, before it bends backward and downward, sends off three branches, and makes also an anastomosis with the common carotid. Of the three branches, the first is sent to the air-bladder, and to the ovaries in the female, and testicle in the male. The second is distributed to the parts about the temple; and the third is the vertebral artery, which, after giving off some twigs to the occiput, enters the canal of the vertebræ, and descends towards the tail. This description of the circulating system, is accurately represented in Plate VII. Fig. 3.

Let us next follow the course of the branchial arteries, destined, as we have seen, to form the gills. Immediately on quitting the branchial arches, they are continued out of the head; and scarcely have they gone out, than they divide into many branches, which, in their turn, subdivide into others, and these, again, into minute ramifications, in such a manner, that the three gills resemble three little plantules, rooted to the sides of the occiput, and furnished with many minute leaflets. The reason why the structure of the gills is so similar to that of a leaf, is, that the fine skin which lines the fauces, invests the arteries as they traverse the arches; and, following them externally, clothes them as they divide: but as they approach their last divisions,

there this skin, instead of surrounding them individually, as it had done in the larger branches, expands into a membrane, which comprises between its two surfaces all the ultimate ramifications into which each lesser branch has spread. A good idea of this foliated structure may be obtained, by inspecting Fig. 4. Plate VII., in which a portion of one of the leaflets is represented, and where the blood of the branchial artery, of a dark colour, is seen moving round the margin of the leaflet. In its course, it continually passes off transversely through the net-work of vessels that forms the expanded portion of the leaflet; and, losing in its progress its dark colour, and acquiring a florid hue, it is finally collected from the several leaflets into the branchial vein at the root of the gill *.

Scarcely have these branchial veins reached the roots of the gills, than they separate from their accompanying arteries, and entering between the extreme points of the arches, proceed superficially towards the top of the spine. The vein of the first gill enters between the first and middle arches, and soon after pours its blood into the *first* branch of the *primary* trunk, or that named Common Carotid. The two other veins, on the contrary, in re-entering the head, pass between the middle and third arches: Afterwards, they unite into a single canal; and thus reunited, they deliver their blood into the second branch of the primary trunk, a little before that vessel sends off its branch to the air-bladder and sexual organs. This distribution of vessels conveying dark blood to the gills, and of those which carry back florid blood from those organs, is represented in Fig. 3., as above. Of the subsequent distribution of

* The authors remark, that the structure of these leaflets of the gills is visible only in *dead protei*, especially in those which, from having been placed in spirits, have lost their transparency. In the living animal, while remaining in water, they can be seen but with the greatest difficulty; and then only when very turgid with blood. The reason is, that the membranous expansions, between which the ultimate ramifications of the arteries and veins are comprised, are so exceedingly fine and transparent that an inexperienced eye is unable to perceive them; and an observer, in such circumstances, being unable to use a high magnifying power, and seeing only the vessels which bound the margins of the leaflets, have supposed the gills to be formed rather like a dissected than entire leaf, or resembling somewhat the horn of a stag.

the blood by the vessels given off from the aorta, it is unnecessary to say more; but of the return of this blood to the heart by the veins, it is proper to take some notice.

There are three principal veins which reconvey the blood from the different parts of the body to the heart; two corresponding to the *jugulars*, and the third to the ascending *vena cava*. The two former, after receiving the blood which returns from the head, pour it into the cava, where that vein is so dilated as to form a sort of sinus. Into the cava, also, at different parts, is poured all the blood returned from the trunk. Thus two large veins which ascend the spine on each side of the aorta, and receive the blood of the dorsal veins in their progress, enter the cava much below the middle of the trunk. The blood of the air-bladder and organs of generation is poured, by a single vein, into the cava about the middle of the kidney. The vein which collects the blood from the intestines, arises near the termination of the alimentary canal; and proceeding between the expanded portions of the peritonæum that form the mesentery, gains the neighbourhood of the stomach: there its trunk, which may be called the *vena porta*, is spread entirely through the concave surface of the liver. After circulating through that viscus, the blood is again collected into one vein, which, traversing the edge of the liver, pours its blood into the cava at the point where that vessel itself quits the liver to continue its course to the auricle.

6. *Of the Organs of Respiration.*

In the preceding chapter on the organs of circulation, the authors have described, with all the accuracy they were able, the course of the branchial arteries and veins to and from the gills, which might be considered as including a description of the respiratory organs; but as the *proteus anguinus*, besides being furnished with gills, is provided also with two air-bladders, which, from a resemblance to the lungs of the aquatic salamander, have been regarded as two real lungs, it is necessary to give a more particular description of those two organs.

In the bottom of the fauces, and exactly in the middle of that space which lies between the branchial apertures which communicate with the gills of each side respectively, there is a

small cleft or chink, the margins of which do not rise above the surface, nor possess a cartilaginous structure. This very small chink or glottis, as it may be called, communicates with a very short canal, which proceeds backwards above the heart, between the pericardium and pharynx. This canal exteriorly, and on the side next the heart, is furnished with two very fine muscular expansions, the fibres of which springing from the median line of the canal itself, are disposed like the beard of a pen, and directed back towards the branchial arches. The office of this very subtile muscular substance is, doubtless, that of dilating the canal, and opening the glottis. The canal itself, before getting beyond the heart, opens, by a semilunar aperture, which has cartilaginous margins, into a large conical cavity, Plate VII. Fig. 2. From this funnel-shaped cavity, are continued two membranous canals, which, keeping the stomach between them, descend towards the tail: but before reaching the lower-third of the trunk, they begin to dilate, and by degrees expand, so as to acquire the form of two small flasks; the left descending a little lower than the right. These two canals are attached to the spine, by duplicatures of the peritoneum, in which, through their whole length, they are involved. The two little flasks or bladders have no cells nor partitions internally, but are perfectly smooth membranes. Were it possible to dilate the two canals to the size of the bladders in which they terminate, these organs would then acquire very exactly the form of the lungs of the salamander. The two bladders are situated one on each side of the abdomen; that of the left side is represented in Plate VII. Fig. I., and also the narrow canal leading to it. In protei that have been some time in spirits, the canals become entirely closed and quite impervious to air; but in those recently dead, the bladders are easily dilated by air blown through the canals.

The authors having observed, that, when a living frog or salamander is laid on his back, the abdomen then opened, and its walls fastened back, the lungs, during the struggles the animal makes, sometimes dilate and contract for a certain time, were desirous of ascertaining, by a similar experiment, if the small portion of air which the proteus takes into the mouth found its way into the two little bladders above described. A proteus

was, therefore, fastened on a board, the abdomen was opened, and its walls kept asunder by means of pins, in order to observe what would happen to the air-bladders. In a few minutes the animal began to take air into the mouth, and afterwards panted with a quickness always increasing for a quarter of an hour; after which his pantings became weaker, and at the end of half an hour he died. While the proteus was thus agitated and panting, they watched attentively the two air-bladders, but did not see in them the smallest movement, which could indicate the entrance of air. They saw, however, that these bladders gradually contracted from the action of the external air; and at length became corrugated to such a degree, as to resemble in figure two fleshy bodies, of the form and size of two grains of wheat. The air which entered the mouth escaped entirely by the branchial apertures, forming mostly minute bubbles, which, for some time, remained attached to the edges of those apertures.

7. *Of the Organs of Generation.*

The authors regret, that, under this head, their observations are not so complete as they could have wished; and that some points relating to it are still enveloped in obscurity.

Of the five protei dissected in the month of May, as before stated, there were two in whom the sexual organs were so fully developed, that no doubt could remain of the one being a male, and the other a female. In the male, the testes were attached to the air-bladder. To the eye they appeared to be a congeries of most minute globules; but when examined under the microscope, their substance was nothing else than a mass of most minute vessels, disposed longitudinally, and extending in a serpentine line from one end of the testicle to the other. Towards the posterior part of the organ, where it had somewhat of a pyriform figure, these minute vessels enlarged and separated a little from ecah other. Continuing the examination, they observed, towards the extremity of the alimentary canal, a circular ring, evidently formed by the internal tunic of the intestine, from which proceeded many longitudinal threads, which extended to the margin of the anus: but nothing was seen like a receptacle for semen, nor penis, nor *vasa deferentia.* A vessel seemed to extend from the posterior part of the testicle, and open into the

intestine; but whether this be the excretory duct of the testicle could not be determined. From an observation of M. Schreiber, the authors conjecture, that the testes of the proteus are subject to some remarkable changes with the increase of years, like those of the aquatic salamander, in which the testicle at first is formed of one spherical body; afterwards of two, and subsequently of three; and not of two only, as M. Cuvier has stated. The position and form of this organ may be seen in Fig. 1. Plate VII. (*g*).

The *ovaria* of the female are situated under the kidneys, and by the side of the rectum. They are enveloped in peritoneum, and have connection both with the spine and air-bladder. In protei recently dead, and not yet put in spirits, the ovaries appear an oblong mass of albumen, in which are suspended a vast number of minute ova. The oviducts do not commence near the heart, as in frogs and salamanders, but towards the anterior third of the trunk. They descend by the side of the spine, along the exterior margins of the kidneys; and having reached the posterior extremity of the kidneys, they approximate and terminate into the intestine by a common aperture, a small distance from the anus. In the proteus dissected by M. Cuvier, he describes "les oviductus tres-longs, et faisant beaucoup de festons, comme ceux de la salamandre;" but the authors have not met with such appearances. In protei preserved in spirits, the oviducts were always found straight; and in those recently dead they were much longer, but did not form those twistings and windings which the ducts of the salamander make before they enter the intestine. See Plate VI. Fig. 3.

8. *Of the Organs of Secretion.*

The kidneys of the proteus are so long as to occupy the lower half of the trunk. In structure, they much resemble those of the salamander; but in their anterior part are two curvatures or sinuses, in which the two air-bladders are respectively lodged. The ureters are much convoluted anteriorly, but extend in a straight line towards the posterior half of the organs, where they gradually approach each other, and finally unite together at their termination by one common aperture in the intestine. It must also be remarked, that, in the male proteus, as in the salamander, the ureters commence high up on the spine, and descend

afterwards in a right line, till they reach the anterior point of the kidneys, where they make many twistings, and pursue a serpentine course, till they arrive at the lower half of those organs. In the females of these reptiles, on the contrary, the ureters are less convoluted, and do not commence at any distance from the kidneys; whence, it is probable, that from this difference of form, the ureters of the male may exercise some other office besides that of conveying the urine. In Fig. 3. Plate VI., the kidney of a female may be seen.

But though the kidneys and ureters in the proteus and salamander bear so near a resemblance, the form of the urinary bladder in the two animals is quite different. In the salamander, this organ is short, and its fundus bifid. In the proteus it is long, and has a simple fundus; so that it resembles more an appendix cœci of the intestine, than an urinary bladder. It is annexed to the intestine in a point diametrically opposite to that into which the two ureters are inserted; in other words, it is inserted into the wall of the intestine that looks downward, while the ureters terminate in the wall that regards the spine. In the proteus, therefore, as in other reptiles of the same family (Batraciens,) the ureters do not terminate in the bladder, but discharge themselves directly into the intestine, at a point opposed to the bladder. This fact has led many, and among others Townson and Schreibers, to doubt if the organ named the urinary-bladder, be, in frogs and salamanders, a real receptacle for the secretion of the kidneys, or destined to some other office. Townson, supposing the urine poured into the intestine by the ureters to be at once discharged with the fæces, suggests the idea, that the bladder above mentioned may be regarded rather as a reservoir of water absorbed from without, and destined to some particular use in the animal economy. His words are, "Cum nunquam bibant hæc animalia, opus tamen sit iis tantopere aqua, probabile mihi videtur, aquam cute absorptam, aut ejus partem induci in vesicam, tanquam in vas quod eam servet; atque inde distribui, prout economia animalis requirat, eodem ferè modo, quo fluidum receptum in ventriculum aliorum animalium inde distribuitur *." That the skin of frogs absorbs water, seems demonstrated by the re-

* See Townson, Observationes Physiologicæ de Amphibiis, &c.

cent experiments of Dr Edwards; but that the water so absorbed is conveyed into the aforesaid bladder is merely a conjecture; and, as appears to the authors, wholly without foundation. But if we reject Townson's conjecture, what must we think of the fluid with which the bladder, both in frogs and salamanders, is so frequently filled? If it come not from the kidney, from what other gland or organ can it proceed? Is it secreted by the bladder itself? This supposition is not probable; for the walls of the bladder are not sufficiently furnished with vessels to secrete so great a quantity of fluid. From some experiments not yet published, the authors are disposed to regard this organ as a true receptacle of urine.

9. *Of the Organs of Sense.*

The *brain* of the proteus very much resembles that of the salamander, especially when in the larva state. The two hemispheres are nearly cylindrical; the lateral ventricles are large, and in their posterior extremity lie the *corpora striata*. There is also a third ventricle, and two optic thalami, very small, and of an oblong form. The carotid artery, on entering the cranium, makes a twist around the aperture, and sends off the opthalmic artery, which is continued, between the cranium and hemisphere, to the eye: the principal trunk of this vessel then proceeds beneath the brain, and, spreading into beautiful ramifications, is distributed to the two hemispheres, &c. See Fig. 4. Plate VI.

The *eyes* of this animal are situated, and we might say buried, between the anterior extremity of the masseter muscles, which go to be inserted in the lower jaw, and the posterior extremity of the canal of the nostrils. They are inconceivably small, and are placed, not in an orbit formed by bone, but in a web or tissue, formed of venous and nervous ramifications. No muscle nor optic nerve has yet been discovered; but on raising the hemispheres very gently, a very subtile nerve, similar to the fine thread of a spider, seemed to go to the foramen, through which passed the ophthalmic artery, as seen in Fig. 4. The crystalline humour is large in proportion to the other parts, and has a spherical figure: the sclerotica is not white, but blackish; of the other parts we dare not say more; for, from their extreme minuteness, it is difficult to speak of them with precision.

The organ of *hearing* in the proteus is very simple. It has neither membrane nor cavity of the tympanum; but consists only of a large cavity formed in the bones of the cranium, in which is seen the little sac containing the *ossicula* or small bones: this cavity is also furnished with a *fenestra ovalis*, closed by a bony plate. On raising the little sac the semicircular membranous canals appeared to come into view, but of this the authors do not speak with confidence. This organ, as seen by them, is represented in Fig. 4., as above.

The organ of *smell* in the proteus differs entirely in structure from that of the salamander, and the other animals of the same family; and if we are entitled to infer the perfection of the sense from the structure of the organ, the *proteus anguinus*, in this respect, will surpass all other known reptiles. The external aperture of the nostrils is exceedingly small, and of a triangular form; its position is represented in the profile view, Plate VI. Fig. 5., and corresponds internally with a canal that is soft and pulpy through its whole length. The olfactory nerves are rather large; these nerves, after passing by the bulbs of the eyes, go out of the cranium, and divide and ramify on the soft substance that lines the nostrils. If with a needle the canal of the nostrils be broken down, and its substance removed, preserving at the same time the nervous filaments distributed upon it, the olfactory nerve is then resolved into a pencil of filaments, as delineated in Fig. 4.

Conclusion.

Having thus terminated the anatomical description of the Proteus Anguinus, the authors proceed to examine the two following questions; *firstly*, Whether it be true, as many believe, that this reptile can respire, at the same time, by gills and by lungs? *Secondly*, If the *Sirena lacertina* is to be regarded as a larva or a perfect animal? To determine these questions, it will be necessary to compare the branchial structure, the organs of circulation, and the supposed lungs of the proteus, with the corresponding parts in the *sirena* and in the *larvæ* of the salamander and of frogs.

With respect to the branchial structure, there is a remarkable difference, not only as to form, but to texture, between the arches of the proteus, and those of the siren and larvæ above mentioned. In the siren and larvæ, the branchial arches are

four on each side, and their margins are furnished with small points,—in the proteus, there are but three on each side, and these are smooth. The arches of the proteus have an osseous structure,—those of the siren and larvæ are cartilaginous. This difference did not escape M. Cuvier, who, speaking of the proteus, says, "l'appareil osseux qui porte les branchies, est beaucoup plus dur que ne l'avons trouvé dans la *sirene*, et dans *l'axolotl*:" and in his anatomical description of the latter animal, he farther says, "*l'apparcil qui supporte les branchies à de grands rapports avec celui de la sirene*, et je crois que, lors de la metamorphose, il en reste une partie pour former l'os hyöide de la salamandre *." Now, if the branchial arches of the siren be, as M. Cuvier asserts, entirely cartilaginous, although the cranium, the lower jaw, and the vertebræ be perfectly ossified; and if these arches, both in form and number, be similar to those of the *axolotl*, which M. Cuvier himself regards as a larva,—may it not be presumed that the former animal is a larva also? If, farther, the branchial arches of the proteus, which is a *perfect* animal, be osseous, and entirely different from those of the siren and all the larvæ hitherto known, have we not in these facts the strongest reasons for regarding the siren as an *imperfect* animal, and, therefore, essentially different from the proteus?

With regard, next, to the organs of circulation, there are, in the larvæ of the frog and salamander, as many arteries given

* The authors here observe, that they have not themselves had an opportunity of anatomising the sirena lacertina; and, therefore, with regard to its internal structure, they trust entirely to the descriptions of M. Cuvier, who has written largely upon it.

It may not be out of place to add, that, in the new arrangement of M. Cuvier, the *Proteus anguinus* stands in the class Reptiles,—order Batraciens,—genus (containing as yet only one species,) Proteus. Besides internal lungs, it bears externally, like the larva of the salamander, three gills on each side of the neck, which it appears to retain through life.

The *Sirena lacertina* occupies the same class and order, and is another genus consisting only of one species. It is said, like the proteus, to retain through its whole life, three gills on each side the neck, and to possess, at the same time, lungs internally.

In the same class and order is placed the Axolotl of the Mexicans, or Sirena pisciformis of Shaw. It belongs to the genus Salamandra, of which it is a species. Some allege that it also always retains its gills.—Vide *Le Regne Animal*, tom. ii. p. 101,—102.—Transl.

off on each side by the trunk that springs from the heart, as there are branchial arches, viz. four. In the siren and axolotl, (which have also eight branchial arches,) M. Cuvier speaks only of six arteries, three on each side, going to the gills; but as, by the aid of injections, we have found, say the authors, that, in the larvæ above named, there are eight vessels, and that the artery which runs along the interior arch of each side, and which M. Cuvier has not seen, is that which in process of time becomes the pulmonary artery, so, guided by analogy, we hold it for certain, that, as the siren is furnished with eight branchial arches entirely similar to those of the other larvæ, there are also eight arteries, four on each side, corresponding to them. And, proceeding on this opinion, we may remark a striking difference in the circulating system of the siren and proteus, since the artery, properly called Pulmonary, which is found in the siren and larvæ above mentioned, does not exist in the proteus. Doubtless in the proteus, the air-bladder, like every other part of the body, is duly supplied with blood; but the blood sent to it is furnished by an artery coming off, on each side, from one of the aortic trunks, and which artery, descending along the canal of the bladder, gives to it a branch, and is then continued to the ovary or testicle in each sex respectively.

Besides these differences in the arterial, there are others in the venous system; for the vessel which returns the blood from the air-bladder of the proteus, does not empty itself directly into the cava or the auricle, as is observed in other reptiles; but into the vein which carries back the blood from the organs of generation, which itself enters the cava above the middle of the kidney: hence in the proteus, not only the true pulmonary artery, but the vein also, is wanting. This anatomical fact, ascertained by repeated injections, might alone be sufficient to demonstrate, that the two air-bladders with which the proteus is furnished are not true lungs: but as some, perhaps, may not yield to the force of these arguments, we shall continue the comparison, especially as applied to the organs of respiration.

In the larvæ of the frog and salamander, the *trachea* opens directly into the lungs. These organs have the form of two sacs, and, from being longer than the trunk, cannot be extended in a straight line through it, but at the lower end are folded

a little from one side of the abdomen to the other. So, in the siren, we see the trachea to open directly into the lungs, which, as in the above-mentioned larvæ, says M. Cuvier, "sont deux longs sacs cylindriques, que s'étendent jusqu' à l'extrémité posterieure de l'abdomen, et se replient même alors en avant." But, in the proteus, neither do the supposed lungs reach to the pelvis, nor does the supposed glottis open into the air-bladders, but issue in a cavity which communicates with the air-bladders by two long conduits. Thus, then, the structure of the branchial arches, the distribution of the bloodvessels, and the form and size of the lungs in the proteus, differ entirely from the corresponding organs in the siren and larvæ of the salamander.

If, farther, we consider the mode in which frogs and salamanders respire air, and compare it with that of the proteus, we shall obtain still farther evidence of the differences subsisting between them. All zoologists, including M. Cuvier, now admit that frogs first receive air into the mouth through the nostrils only, and from thence force it into the lungs by an action resembling deglutition. But neither the proteus nor the siren are able to respire in this manner; for the nostrils in the former do not open into the mouth, but beneath the upper lip; and in the siren, "*les narines, simplement creusées sur les côtés du museau, ne pénètrent point dans la bouche,*" says M. Cuvier. Neither do these animals respire air in the manner of serpents, for they are both destitute of ribs. When also the proteus takes air into the mouth, it escapes rapidly through the branchial apertures: nor is there any ground for believing that any portion of it enters the very narrow chink of the glottis to pass into its cavity, and from thence through the two membranous canals into the air-bladders. No muscular structure suited to produce such effects exists, and the fine membranous canals, subject to compression every instant from the stomach, altogether unfit them for performing the office of air-tubes or bronchi. In all reptiles that respire air, the structure of the organs is such as to permit free inspiration and expiration, however different the form may be; but in the proteus, the want of ribs and diaphragm, the fact that the nostrils do not open into the mouth, the extreme narrowness of the aperture termed glottis, and the narrowness, length, and compressibility of the

air-tubes, all shew, that in this animal none of those arrangements exist, which nature has instituted with such great solicitude and skill in other reptiles, to carry on with ease and certainty the respiratory function. But it is needless to multiply arguments, to prove that the air-bladders of these animals in nowise perform the office of lungs, since it has been already shewn that, when taken out of the water, they die just as fishes do.

M. Cuvier justly observes, that those animals can alone be deemed truly amphibious, "qui respirent, à la fois, l'air élastique en nature, et celui qui contient l'eau:" and he then goes on to state, that the *sirena lacertina* respires through its whole life by lungs and by gills, and is therefore a permanently amphibious animal; but that the larvæ of other reptiles make use of these two different organs only for a short period, and are therefore only temporarily amphibious. With all due respect, however, to so great a zoologist, we, say the authors, are of opinion, that before pronouncing the siren to be permanently amphibious, it would have been proper to have made upon it, or upon animals which resemble it, experiments similar to those we have made on the proteus. If, in his researches with regard to ambiguous reptiles, he had not contented himself with examining only their skeletons, but had examined also the *larvæ* of the salamander, while yet alive, we are certain that his investigations would have conducted him to opinions entirely opposite to those which he has been led to form.

In our investigations on this point, we have directed our attention to the above mentioned larvæ, to observe particularly the changes which occur in their intimate structure, when they are transformed into *perfect animals* *. Between the siren and these larvæ there is the greatest resemblance, not only in regard to the structure of the branchial arches, but also to the nostrils; for, in the siren, as well as in these larvæ, the nostrils do not

* The investigation here referred to, is contained in a memoir, entitled, "Descrizione Anatomica degli organi della circolazione delle Larve delle Salamandre Aquatiche, fatta dal Dott. Mauro Rusconi," Pavia, 1817. The substance of this memoir, we may, on a future occasion, communicate, from a belief that few questions, either in a zoological or physiological view, possess greater interest, or are at present less clearly understood, than the structure and transformation of these supposed amphibious reptiles.—Transl.

open into the mouth. This circumstance prompted us to examine the condition of the bones of the face in these larvæ, and we have thereby satisfied ourselves that the larva of the salamander is unable to breathe by lungs, until the maxillary bones, the zygomatic arches, and the palatine bones are sufficiently developed to form the canal of the nostrils, in such a manner that its posterior extremity may open into the mouth. Before this canal is so formed, these larvæ are unable to respire atmospheric air, and, if taken out of the water, they then soon die; and, therefore, guided by analogy, we incline to the belief, that, to the siren, whose nostrils " ne pénètrent point dans la bouche," the same things ought to happen. Moreover, as its lungs are similar in all respects to those of the salamander, and are furnished with a true glottis, we are farther of opinion, that the siren is the larva of some reptile, the genus of which is as yet unknown, and which will differ from its larva in not possessing gills, and in having a trunk somewhat longer.

To return to the proteus.—We consider that it is not an amphibious animal, having a double circulation, as some have maintained, but a *perfect reptile*, different entirely from all others. It is a reptile, in respect to its having a single circulation, and a fish, in regard to its mode of respiration,—in other words, it is a reptile which respires air mixed with water, while others respire atmospheric air: so that, were it allowable to revive the old idea of a chain of beings, the proteus might be regarded as the link which would connect reptiles with fishes.

From the facts and circumstances above stated, it appears, that the proteus is an animal, which, like fishes, is capable of respiring only in water. Its branchial circulation, however, is only a fraction of the greater circulation, whence it follows, that, in respiration, it consumes less oxygen than fishes do; and, consequently, a smaller quantity of blood in a given time is changed in the gills of the proteus, than, in like circumstances, is changed in the gills of fishes. From this circumstance, as appears to us, continue the authors, arise the inertness, the slow growth, the capacity of enduring fasting, the indisposition in the blood to coagulate, and, lastly, the power of living in a stagnant water, where a fish of equal size would die. With regard to the faculty of generating heat, the authors are unable

to speak with confidence: on this and some other points they were unable to satisfy their curiosity, having sacrificed all the protei which they possessed to other researches.

The reader perhaps may expect, that after having thus set aside the common opinion, that the two air-bladders of the proteus perform the function of lungs, we should declare the purpose they are designed to serve. This, however, say the authors, it is difficult to do, as it is to say what is the true and primary use which the air-bladder serves in fishes; but this point, at a future period, they hope to be able to investigate, both in the protei and in fishes.

Such is a condensed account of the labours of Professors Configliachi and Rusconi, regarding the history and structure of this singular animal. Those who may desire more minute information, must consult the work itself, and more particularly the numerous and beautiful figures, designed by Dr Rusconi, and engraved by Anderloni, with which the work is adorned.

D. E.

Explanation of Plates.

Plate VI. Fig. 1. View of the head from below, eight times greater than natural. *aa*, the two branches of the lower jaw; *bb*, processes of the temporal bones to which they unite; *c*, the roof of the palate; *d*, the os hyoides; *eee*, the three branchial arches of the right side; *fg*, the intermediate bones of the first and second arches; *hhh*, the three first vertebræ; *nn*, the branches of the os hyoides.

Plate VI. Fig. 2. The skeleton of the proteus of its natural size; *a*, the three cartilages, forming the shoulder; *b*, the pelvis.

Plate VI. Fig. 3. The lower half of the trunk of a female proteus laid open. *a*, the alimentary canal shortened and straitened from the action of ardent spirits:—at its termination, it is slit up to shew the common *focus* of the ureters and oviducts, into which two bristles are inserted, the opening from the urinary-bladder is indicated by a single

bristle; *b*, the left *ovarium*, containing minute *ova*, and drawn to one side to display the kidney underneath; *c*, a portion of the oviduct straitened by the action of the spirits; *d*, the left kidney; *e*, the ureter running along its margin, and terminating with the oviduct in the *rectum*; *f*, a portion of the left air-bladder, in this instance remarkably enlarged; the corresponding one of the right side was very small.

Plate VI. Fig. 4. The cranium laid open, to shew the cerebral mass and certain nerves springing from it; *aa*, the two hemispheres of the cerebrum; *b*, the cerebellum; *c*, the medulla oblongata; *d*, the right olfactory nerve; *e*, the origin of the fifth pair of nerves; *f*, the vestibule of the organ of hearing laid open, in which the little sac is seen, and the origin of the acoustic nerves; *g*, the facial nerve; *h*, the entrance of the carotid into the cranium, from which springs the opthalmic going to the eye (*n*); *m*, the origin of the par vagum.

Plate VI. Fig. 5. Profile of the head and part of the trunk; *a*, the external aperture of the nostrils surrounded by pores; *b*, the doubling of the inferior lip, which is in part covered by the superior; *c*, the swelling or protuberance produced by the heart.

Plate VII. Fig. 1. A male proteus laid open, to exhibit the relative size and position of the viscera; *a*, the heart, with its pericardium, opened and turned back; *bbb*, the liver drawn aside, to shew the viscera beneath it; *c*, the stomach; *d*, the alimentary canal; *e*, the spleen; *f*, the pancreas; *g*, the testicle of the left side; *h*, a part of the left kidney; *i*, the urinary-bladder; *k*, the left air-bladder, with its tube, opening into the conical cavity above; *l*, the anus or cloaca; *m*, the sinus of the vena cava.

Plate VII. Fig. 2. *a*, the heart reversed and turned upward; *b*, the short conical canal cut longitudinally, which communicates anteriorly with the glottis, and posteriorly with the cavity from which the two tubes, (*cc*) terminating in the air-bladder, proceed.

Plate VII. Fig. 3. Head of the proteus viewed from below, eight times greater than natural, displaying the circulating and respiratory systems; *a*, the heart; *b*, the arterious trunk spring-

ing from it; *c*, its bulb; *dd*, the two primary trunks arising from the bulb, and again subdividing; *e*, the first branch of the primary trunk, or artery corresponding to the common carotid, and which subdivides into two, one branch (*f*) being continued to the first or exterior gill, and the other (*g*) proceeding to the muscles of the os hyoides; *h*, the vein which carries back the florid blood from the gill.

The second branch of the primary trunk (*d*) soon also subdivides, sending off the branch (*i*) to the third gill, and another (*l*) to the middle gill. To these two branchial arteries, the two veins (*mm*) which carry back florid blood, correspond. The principal trunk of this second branch, after receiving this florid blood, sends off the artery (*n*), which, descending along the air-tube, supplies the air-bladder and generative organs in each sex; it then curves upward, and from its curvature gives off the vertebral artery (*o*), which, after sending some twigs to the occiput, enters the vertebral canal, and descends along it: it also gives off another branch (*p*) to the temporal bone, and then making another curvature downwards, it becomes a branch (*q*) of the aorta, which, by uniting with its fellow of the opposite side, it contributes to form. The aorta (*r*) gives off the branchial arteries (*ss*), the mammary (*u*) and the vessel *t* going to the stomach; the letter *x* denotes a portion of the vena cava cut off.

Plate VII. Fig. 4. A leaflet of the gill highly magnified, exhibiting the branchial artery (*a*), conveying dark blood to the gill, and the branchial vein (*b*), returning florid blood to the aorta.

Art. XVII.—*Account of the New Galvano-Magnetic Condenser invented by* M. Poggendorff of Berlin.

The beautiful experiments of M. Ampere on the action of spiral conductors, which we have described in our last Number, have thrown much light on the new science of electro-

magnetism, and will, we are persuaded, lead to a more perfect knowledge of the nature and formation of natural and artificial magnets. A spiral apparatus of a different kind, but suggested probably by Ampere's instruments, has been recently invented by M. Poggendorff of Berlin, and has received the name of a Galvano-Magnetic Condenser. Through the kindness of Dr G. Forchhammer, an able Danish chemist, who has spent a few days in our metropolis, on his way to examine the statistics and mineralogy of the Faroe Islands, we have been enabled to present a notice of it to our readers, as contained in a letter which he has recently received from Professor Oersted of Copenhagen.

The Galvano-Magnetic Condenser is represented in Plate I. Fig. 16, where *a b c d* is a spiral wire, having between 30 and 40 spires. This wire is covered over with silk thread, (in the same manner as the strings of a harpsichord are, with brass wire,) and one end of it *a*, for example, is placed in contact with a zinc plate, while the other end of it *d*, is placed in contact with copper. The zinc and copper plates are each in contact with a humid body, such as dilute nitric acid, &c. When the apparatus thus prepared is established vertically, as in the figure, and an *unmagnetised* needle *m n*, supported upon a stand S, is placed in the axis of the spiral, it will become magnetical, and will arrange itself in the magnetic meridian. M. Oersted remarks, that the unmagnetised needle is in this case a much more delicate test of galvanic action than even a frog itself. D. B.

Art. XVIII.—*History of Mechanical Inventions and Processes in the Useful Arts.*

—"The seat of the Useful Arts,—of those which mankind bless, and by which they are blessed,—of those which the heart reveres, and the understanding approves, is Britain."—*Edin. Rev.* Vol. xxxii. p. 388.

THOSE who wish to form a correct estimate of the comparative extent and resources of British industry, must gather their information from a visit to foreign countries, and decide upon the evidence of their own personal enquiries. Accustomed as

we have always been to speak and hear of our own pre-eminence in the useful arts, and exaggerated as those opinions generally must be that are formed under the influence of national partialities, yet the estimate formed by untravelled Englishmen of our manufacturing industry is far beneath the truth; and we are persuaded that they have only a faint conception of those substantial comforts which the ingenuity and industry of their countrymen have added to the hourly enjoyment of all classes of the community. Greatly, however, as we do excel all other nations in the productions of the useful arts, we think it will scarcely be denied that our superiority may still be increased; that a great portion of our manufacturing skill is neutralised by the financial condition of the country; and that the measures of rival industry, which have been so vigorously pushed by foreign states, can only be opposed by the most liberal and efficacious excitement of mechanical talent. The condition of our patent laws, and their frequent administration under the most deplorable ignorance of British interests, have left this country in the singular predicament of being the only nation in Europe which has withdrawn from the safeguard of the law the great products of mechanical skill; or to speak more correctly, which holds out to inventors an illusory privilege, which sells to them that privilege at an enormous price, and which yet refuses to defend from direct invasion, or legal sophistries, what it has solemnly stamped with the Great Seal of England. This unnatural warfare, which the law of patents has so fatally waged against the useful arts, is by no means the fault of the Government. It has arisen from a want of spirit, and combination, among patentees themselves, from the commercial jealousies of rival manufacturers, and from a prevalent but erroneous notion, that patents are monopolies which impede the free current of trade, and encroach on the commercial liberty of the subject. When viewed in this light, it is not to be wondered at that a few hundred inventors should find their interests opposed by the dull crowd of manufacturers whom they have outstripped in ingenuity, or by the great body of the public, who suppose that they have a direct interest in the abolition of an exclusive privilege. But we confess it does surprise us, that men of more liberal views should have so long countenanced this crusade against the arts, and that those who

have struggled so keenly for some speculative improvements in our constitution, should have overlooked those palpable encroachments which the administrators of the law have gradually made upon rights so highly respected by the law itself, and so dearly cherished even under the most despotic institutions *.

The Society established in London for the encouragement of Arts and Manufactures, is the only public establishment which has interposed its labours in behalf of mechanical genius; its efforts have been attended with the best effects, and though sometimes misdirected, they have always been guided by zeal and patriotism. It is deeply to be lamented that Scotland possesses no such institution; and that the profusion of mechanical talent which characterises this part of the island, should be thus allowed to languish in obscurity. For many years we have had occasion to deplore this unprotected state of the useful arts. Without a journal, in which inventors could give publicity to their views; without a man of science almost, who would take the trouble of assisting them with his opinion and advice; without the means even of exhibiting their inventions; and without a fund out of which they could be rewarded, we have seen the most ingenious men retire with disgust from the prosecution of their inventions, while others, better fitted to struggle against neglects and disappointment, have ruined themselves and their families by aiming at those speculative advantages which the phantom of an exclusive privilege held out to their ambition. We trust that individuals of public spirit and influence will give their assistance in removing this reproach from our metropolis, by the establishment of a Society of Arts, or by some modification of the Board for Manufactures and Fisheries, by which that valuable institution may be made to embrace a wider and more useful range.

With the view of promoting as far as we can the advancement of the useful arts, we have resolved to devote a portion of each volume of this Journal to a history of mechanical inventions and useful processes, and we shall pay every attention to

* The two Bills now before Parliament for amending the law of patents, and securing the rights of inventors, deserve in some shape or other the support of every friend of his country.

the communications which our correspondents may from time to time transmit to us on these subjects.

1. *Method of Propelling Steam Boats, without Wheels.* By J. B. Fraser, Esq. Edinburgh.

The great increase of steam-navigation has rendered it an object of no small importance to simplify and improve the machinery of steam-boats, and the great advantages that would arise from adopting them on artificial canals, has made it particularly desirable to discover some new method of propelling vessels without the use of wheels. M. Bernoulli was, we believe, the first who suggested the idea of impelling boats by a jet of water. He proposed to fix in the boat an upright tube, in the shape of the letter L, the vertical part having a sort of funnel-top convenient for filling the tube with water, which descending through the horizontal part, and issuing in the middle of the stern, but below the surface of the water, should propel the boat by the re-action of the effluent stream. An improvement upon this contrivance was suggested by Dr Franklin, who proposed to add another tube of the shape L, "the two standing back to back, the forward one being worked as a pump, and sucking in the water at the head of the boat, would draw it forward, while pushed in the same direction by the force of the stern. And after all, he adds, it should be calculated whether the labour of pumping would be less than that of rowing. *A fire-engine might possibly in some cases be applied in this operation with advantage.*" Dr Franklin then proceeds to shew how the boat might be moved by the use of air in place of water, and he suggests the use of an air-vessel properly valved to permit the force to continue, while a fresh stroke is taken by the lever.* In 1818, Dr Jeffrey of Glasgow took out a patent for propelling steam-boats by drawing and then forcing out through the same tube alternately, by means of a piston, a current of water in a direction parallel with that in which the boat was required to move; but there were particular objections to this contrivance, which we understand have prevented it from coming into use. A similar

* See the Memoirs of the Life and Writings of Benjamin Franklin, Vol. vi. p. 451. Lond. 1819.

method of impelling steam-boats has been lately proposed in the *Annales des Mines* for 1820, p. 194, by M. Clapeyron, who does not seem to have been acquainted with the labours of preceding inventors. He supposes A and B, Fig. 4. Plate I. to be two apertures formed in the fore part of a boat, and communicating with a pump DA, in which is moved a piston P, driven by a steam-engine. If valves properly adjusted are placed at A, B, C, and D, the alternate motion of the piston will communicate to the water entering successively at B and A a force depending on its velocity, and on the ratio of the diameter of the body of the pump, and of the tube EF. This tube may terminate any where, provided its axis is parallel to the direction of the current; and the force which acts upon the boat will be always upon the side of the tube opposite to the orifice. By varying therefore the position of the orifice, and consequently the direction of the pressure, the boat may be easily guided without a helm. For this purpose, it will be sufficient to perforate the tube E F with lateral apertures, which may be opened or shut at pleasure. M. Clapeyron supposes that the pipe E F should reach to the extremity of the boat, and that the water rushing in to fill up the vacuum might diminish the resistance of the current. He recommends also, that the orifice by which the water enters should be as high as possible, and that by which it issues as low as possible.

In the year 1820, a joint patent was taken out by J. B. Fraser, Esq. and G. Lilley, Esq. for propelling vessels by forcing out a small jet of water by means of compressed air. This very ingenious contrivance, which, however, has not yet been put in execution, on a real steam-boat, is represented in Plate I. Fig. 5, 6, 7, 8, 9, where A B C D, Fig. 5, is a longitudinal section of the boat, and B C its keel. A cistern, or condensing reservoir, E F, placed near the bow, has a main tube G descending from it, with a plug H, that may be opened and shut at pleasure. Two tubes, L L, Fig. 5, 6, branch off from G G, each of them having a plug O, by which it can be opened or shut at pleasure, and extend to a point rather nearer the bow than the centre of gravity of the vessel. The main tube G, after reaching a point Y, about one-third of the length of the vessel from the stern, divides into two tubes M M, Fig. 5, 6, which

bend back at Y, as shewn in the figures, and have the same diameter as those at L, with valves, opening outwards at their extremities. At the point S, beyond the junction of L L, the tube G is provided with a plug, by which it may be opened or shut at pleasure. Immediately above the tube G G is placed a tube R, which communicates with the suction-pipe of the pump for supplying the cistern E F with water, and which divides into two branches *h h*, Fig. 5, 6, which descend into the water on each side of the keel, and point aft, as in the figures. Above these branches is a plug P, by which the communication with the water may be opened or shut; and there is a third tube, *g g*, proceeding from both sides of it above the plug P, and proceeding at both its ends into the inside of the vessel, so that one end of it, by means of the plug *q*, shall draw water, while the other end, by the plug *s*, shall draw air from the inside of the vessel. Grates are placed at the end of the tubes *h h*, to keep out weeds and rubbish.

The tube R communicates with E F by means of a tube V, with a stopcock placed below the plug P, that in case the tubes *h h* be obstructed, the engine may be stopped for an instant, and the plug H shut, so that water being admitted from E F, by opening the stopcock, it will force out the obstruction.

To the after side of E F, a pump of any convenient description is applied, having its suction-pipe fixed on the tube R, and discharging itself into the cistern at N. By the operation of the plugs *q* or *s*, this pump may be made to pump air or water that has lodged in the hold, or, by shutting them, and opening the plug P, to pump water from the water on which the vessel floats into the condenser at N, through a valve opening into the cistern.

The machine acts in the following manner. When the plug H of the pipe G is shut, the condenser E F is pumped half full of water, and the plug P being then shut, and *s* opened, air is pumped into E F, until it is ascertained by a common safety-valve T, that it contains as much air as it will sustain. The plug *s* being again shut, and *p* opened, so as to pump water, and the plugs H and O, O of the descending tube opened, and that at S shut, the water will proceed with great velocity through the tube G, and issue at the tubes L L (as long as the

quantity in the cistern is kept up by the pump) with such force as to propel the vessel forward. But if the plugs O O are shut, and S opened, the water will issue through the tubes M M, and give the vessel stern-way.

In order to turn the vessel round, four tubes I, I, I, I, may be attached to the sides of the tube any where between the plugs H and S, and carried to the head and stern of the vessel, so as to terminate at *t*, *t* and *a*, *a* at right angles to the keel. The plugs are united transversely, so that either pair being opened, the water may issue near the bow on one side of the keel, and near the stern on the opposite side of the keel *a a*. These plugs are situated at *b*, *b*, *b*, *b*, with piston rods connected by pairs, as shewn in Fig. 7, but transversely. When great dispatch in turning is necessary, the plugs at S and O O must be shut.

The condenser E F has a tube X, extending from its upper part to within a foot of the bottom, and through this tube the water will rise, in order that its power may be measured by means of an ordinary safety-valve T, applied to the upper end of the tube, and so adjusted as to allow the water to issue when its power is greater than what the condenser can properly sustain.

The plugs O O have piston-rods *r r* attached to them as in Fig. 7, and united at *e*, so as to act together by means of the single piston-rod *d*.

The plug at S is constructed as shewn in Fig. 8 and 9, the former being a cross section, and the latter a longitudinal section. A piston W, with a piston-rod *r*, passing through a stuffing box, may be forced into the lower cylinder, so as to stop the main tube G at that place, and, being drawn up again, shall leave that tube open. This piston must be rendered pervious to the water by one or two tubes in the same direction with its piston-rod, to admit of its ascent or descent into the water. The plugs O O and H may be constructed on the same plan with S, and all of them must be perforated by a strong copper piston-rod *s s*, passing through a stuffing box in the lower end of each cylinder, to direct and enable them to withstand the pressure of the water in their ascent and descent.

The machinery which has now been described, with the exception of the tubes for repelling, and those for turning the

vessel quickly, has been fitted up on board of a boat by Mr James Milne, under the inspection of Mr Fraser, the inventor, so as to be wrought by two men, who pulled at separate levers, in the same manner as the rowers pull at the oar. By means of two apertures, each of which was only one-fourth of an inch in diameter, the boat went at the rate of three miles an hour, though the machinery laboured under an imperfection, which has since been remedied.

2. *On the Substitution of Block-Tin Pipes in place of Copper ones, and on the Construction of their Joints.* By Mr James Milne, Brass-Founder, Edinburgh.

In the month of June 1817, being then in London, I happened to see a piece of copper-pipe, originally $\frac{5}{8}$ths of an inch bore, which had been used for conveying coal-gas, so furred up, that the opening in the centre would scarcely admit a crow-quill; and I was informed that several shops which had been lighted with coal-gas for eight or ten years were obliged to be refitted with new copper-pipes, the old ones being quite useless. These circumstances first induced me to think of substituting for that purpose pipes made of some other metal, which might obviate the objection to copper, of being subject to the corrosive influence of coal-gas.

Pure block-tin occurred to me as a metal less liable to be acted upon than any other, possessing considerable ductility, and sufficiently strong when made of a proper thickness. Soon after my arrival at home, I tried to make a piece of block-tin pipe, cast upon a mandril, and drawn down to a proper thickness, say $\frac{1}{16}$th of an inch. In this trial I succeeded far beyond my expectations, by turning out a pipe, not only nearly equal in appearance to silver, but also capable of bearing a very great external pressure without flattening. Previous, however, to introducing this pipe to the public, about the close of the year 1817, I took to Glasgow a piece, of $\frac{1}{2}$ inch bore, and the usual thickness $\frac{1}{16}$th, in order to have it tried by a very powerful pump used at the gas-works there, for proving the pipes, to ascertain what pressure it would bear. Next day the sub-engineer returned it to me, saying he had applied to it the greatest power the machine was capable of, equal to a column of water 1000 feet high, without being able to burst it, or even injure it in the smallest

degree. After this trial, and the approbation of all the gas-engineers to whom I shewed it, I felt confidence in recommending it to the public.

I now proceeded to make tools for manufacturing tin-pipes of all sizes from $\frac{1}{4}$ to $1\frac{1}{2}$ inch internal diameter, and have continued to use it ever since in preference to copper-pipe without a single complaint.

The principal advantages I conceive block-tin pipe to possess over any other, are, *First*, Its being less liable to be acted upon by gas, and from the nature of the metal not likely to oxidate or corrode. *Second*, From its ductility it is easily bent to suit the different situations required; and as the joinings are made with solder nearly of the same nature as the pipe itself, any blow or strain the pipe may receive at or near a joint can do little injury, as both the solder and the pipe will yield together, and never produce a leak, as copper-pipe, if put together with soft solder, is apt to do when subjected to the supposed strain. Copper-pipe is sometimes joined with screwed ferrules, which I think are more liable than solder to give way on getting a strain; the surface being cut with the screw renders it weak, and therefore easily broken. *Third*, The facility of joining it is of considerable advantage, a considerable item in gas fittings being the men's time occupied in laying the pipes. By the mode I use, (see Plate I. Fig. 10), any ordinary workman will make a perfect joint in less than two minutes, equally strong with the pipe itself, without a possibility of diminishing the internal diameter a hair's breadth, and not increasing the external diameter above $\frac{1}{16}$th of an inch, which, if properly dressed off, at a distance of 5 or 6 feet, is not perceptible.

From the construction of these joints, it occurred to me that a pipe might be joined and soldered while full of water. I tried the experiment in presence of a scientific gentleman, and completely accomplished it under a pressure of a three foot column of water.

If the beauty of the pipe were to add any thing to the price, most people would dispense with it; but as it creates no additional expence, its clean and polished appearance certainly gives it a preference, where pipes are exposed to view, as they are in many cases.

Fig. 10 of Plate I. represents the method of joining two block-tin pipes A, B at C. D is the connecting ferrule, made of brass, about $\frac{1}{32}$th of an inch thick, turned to a knife-edge at both ends, leaving the centre ridge the whole thickness of the brass. E, Fig. 11, is a steel mandril, turned from 1 to 2, exactly to fit the bore of the pipe; it is bevelled from 2 to 3, the same as the connecting ferrule. When you make the joint, drive the mandril into the pipe up to the mark 3; take out the mandril, and the pipe will have a bevel corresponding to the slope of the ferrule. This being done at both ends of the pipe, insert the ferrule, and press the pipe close: the inner surface of the pipe and the outer surface of the ferrule being true to each other, the joint will now be air-tight, when it is very easily soldered, and, when done, is fully stronger than any other part of the pipe. When it is required for conveying liquids, the ferrules are tinned. By this method the joints are very easily made, and there is no risk of making a bad one, or any possibility of the internal diameter of the pipe being diminished, by solder getting in at the joints. These ferrules are made from a penny each and upwards, according to the size of the pipe.

3. *Description of a New Shower-Bath.* By Mr John Murray, Lecturer on Chemistry, &c.

In Fig. 12, Plate I. is represented a shower-bath on, I believe, a new principle. The figure exhibits a cistern C, to be filled with water for the purpose of supplying the machine, together with a stopcock S, to let that water occasionally run off. Over this is placed a shallow basin B, serving as a complete cover for the cistern, and having a slip or false perforated bottom, through which the falling water percolates, and forms at the same time the platform on which the patient stands.

Towards the summit is a vase V, with a perforated bottom, (there may be reserve ones with apertures of varying diameter, to screw and unscrew at pleasure, so as to modify the shower and shock for specific purposes), and to this vase, above is attached a lever L, which, by means of a spring, shuts an aperture somewhat in the manner of a flute key; the lever is managed by means of a cord M at its extremity.

The vase, when it is to be supplied with water, is lowered into the cistern by means of a small winch W: this winch has a recoil

spring to prevent its descent, when raised to the required elevation; and to preserve its movements uniform and steady, the vase travels in a groove *g g* on both sides. When the moveable basin B, which receives the descending shower, is removed, and the vase lowered into the cistern, the lever is raised to allow the ingress of the water, and then suffered to recover its spring, when it is elevated by the winch. The perforated slip bottom of the moveable basin should be of wood, which will be more comfortable for the patient, while the vase and cistern may be made of tinned sheet-iron.

The principle is very simple, and easily apprehended, the column of water in the vase is supported by the resisting atmosphere; and the great superiority of the bath in this form consists in the *numerous repetitions* which may be made from the *same supply* of water, while the *duration* of each is under the complete controul of the patient. The intermissions may be *abrupt or lengthened*, and the water suffered to descend either like a *gentle dew* or in a *full torrent.*

This shower-bath has been highly approved of by those medical gentlemen and men of science to whom I have explained its principles. In the model it operates admirably, and I have reason to believe that some have been already constructed.

4. *Method of fastening the Seams of Hose for Fire-Engines, and of connecting two or more Lengths of Hose together.* By Jacob Perkins, Esq.

The first idea of rivetting hose, instead of sewing them, belongs to Messrs Hancock and Sellers of Philadelphia, and has been successfully practised more than ten or twelve years. Mr Perkins, however, recommends that the leathers should be more overlapped, and has invented a method of connecting two hose without contracting the water-way at the joints. These improvements are shewn in Plate I. Fig. 13, 14. The rivets represented in Fig. 13. are made of copper, which not only last four or five times longer than the best thread, but if the overlap is sufficient, the pressure of the water against the overlap acts as a valve to tighten the seam. As the portion of the hose next the engine has been found to burst most frequently, especially when the water is carried perpendicularly, the first, third or fourth por-

tions are double-rivetted as in Fig. 13, the rest having only a single row. When a rivet breaks, it is replaced by making an opening in the seam, of sufficient size to allow the hand to replace not merely the rivet that is broken, but those taken out to form the opening. When the rivets are fixed in the holes, they are rivetted by placing them upon a flat bar of iron, introduced in the entrance of the hose. The rivet and burr should both be of wrought copper, and not of different materials. Tin rivets, for example, with copper burrs, in consequence of the galvanic action, will destroy the leather in a few months.

The method of connecting the hose is shewn in Fig. 14, where A is the female part of the swivel joint attached to the hose by the female screw *cc*, and prevented from collapsing by the brass ring *d*, within it. On the outer side of this screw is a groove, *bb*, on which the swivel ring *a* revolves; this ring being fixed to the female connecting screw, B, by means of rivetting over the end of it at *f*. The male screw C, is attached to another portion of hose in the manner already described.

The different pieces of leather that compose the hose are connected by a spiral joining of double rivets.

For farther information respecting this invention, see the *Transactions of the Society of Arts*, vol. xxxviii. p. 102., from which the preceding account has been abridged.

5. *On forming a Communication with the Shore in Shipwrecks, and on instantaneous escapes in cases of Fire**. By Mr John Murray, Lecturer on Chemistry, &c.

The invention of Captain Manby, beautiful and valuable as it is, is not always available. The rope frequently snaps, and

* An apparatus for saving lives in cases of shipwreck, by Mr H. Trengrouse, has been described in the 38th volume of the Transactions of the Society of Arts, p. 161. The projecting force used in the apparatus, is a *rocket*, and it was found that a rocket of 8 oz., with a mackerel line attached to its stick, ranged to the distance of 180 *yards*, and that a pound rocket in similar circumstances ranged 212 yards. The rocket is placed in a copper instrument at the end of a musket charged with a small quantity of powder without wadding, for the purpose merely of directing and igniting the rocket. The rocket, when lighted by the powder, burns for a few seconds before it acquires sufficient momentum to quit its situation, during which time the combustible would be ejected into the barrel of the

it is difficult so to manage the required elevation, that the parabolic curve be adjusted to the distance and position. In a recent instance, off Whitby, the shot in the first experiment fell short, and in the second the rope broke.

The disastrous circumstance of a shipwreck off the coast of the Isle of Man, (in which the unfortunate crew and passengers, to the number of about thirty, were consigned to the watery abyss, at a distance from the shore, not exceeding fifty to sixty yards,) first led me to consider the practicability of using the *common musket* in like cases, and where the distance was not considerable.

I could enumerate many instances of shipwreck, where the means now proposed would have been happily efficient, as at Aberdeen, Montrose, &c.

In my first experiments in the summer of 1817, made in the Isle of Man, with Captain Garbett, R. N., and several other gentlemen, a musket bullet was employed, to which whip-cord was fastened, for it occurred to me that whip-cord might be strong enough to bear a log-line, and this last to carry a rope on board. In all my experiments, however, the cord broke, and the like issue took place with silk, catgut, and hair-cord. I found that the string, &c. snapped *within* the barrel. I presumed, that if a substance could be found of sufficient power to carry the ball beyond the orifice, it would finally succeed, but every experiment had similar terminations.

Towards the close of last autumn, I made experiments of a different kind, and with highly successful results, and since that period they have been repeated with the same success.

Arrows of hickory or ash, loosely fitting the calibre of the musket, are discharged with gunpowder, the charge being rather less than the usual quantity. The arrows are three or four inches longer than the barrel of the musket, and are shod with iron at the point, having an eye, through which the line is threaded. The lower end enters a socket, which must be in complete contact with the wadding of the piece.

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gun, if it were not prevented by a loosely suspended valve, which opens to permit the passage of the charge, but immediately closes, and hinders the barrel from being choaked by the retrograde discharge from the rocket.—D. B.

A soldier's musket or blunderbuss, will doubtless serve the purpose better than a fowling-piece, but either will succeed; and it is important to observe, that the line *never snaps*, and the average distance to which the *arrow and a log-line* were projected, may be estimated at 230 feet;—though in *one* case an iron-rod was carried 333 feet, but in this instance the line was favourably placed. It is obvious that a smaller line would be propelled farther, and, when aided by the breeze, which would be most effectual, if the arrow was launched from on board toward a lee shore, the distance would be greatly extended, and in that case a plumed ruff might surround the shod summit of the arrow, inclining toward the eye.

It must also be remembered, that as the experiment may be repeated from on board, the distance assigned to the flight of the arrow would be *doubled*. The one from on shore should have a small float-board to preserve the buoyancy of the arrow on the waves, and in the dark and stormy night, carry a port-fire, to mark its transit through the atmosphere, and guide the aim from on board.

Moreover, the life or other boat can generally, if not always, get sufficiently near the shipwreck, to propel the line on board by the method proposed.

In some parts of the country, a rope fastened to posts is stretched across rivers, by means of which letters, &c. are conveyed to the opposite side; now, after heavy floods this may be, and often is washed away, but, by means of this invention, the communication may be promptly restored.

This may also be employed to branch the harpoon in the whale-fishery. These experiments also explain the cause of the rope breaking in Captain Manby's mortar, while they point out a method by which that misfortune may be remedied, and shew that the *swivel* may be substituted.

There still remains another interesting application of the invention. The arrow may be projected over lofty buildings on fire, and carry a line attached to a lengthened *rope-ladder*, which could be drawn over the roof to the other side, and thus *instantaneously establish a fire escape* for the unfortunate inmates from the roof (the last pedestal in cases of fire,) on both

sides. The ends of the rope-ladder should be fastened into the pavement by means of iron-staples.

6. *Account of an improved Glaze for Porcelain.* By Mr John Rose *.

The common glaze for porcelain and the finer kinds of earthen-ware, contains glass of lead, which is extremely liable to combine with and degrade the more delicate colours, especially those obtained from preparations of chrome and of gold. This is particularly the case with those elaborate products which require to be repeatedly heated or fired.

The chief ingredient of Mr Rose's glaze is pale flesh-red coloured feldspar of a somewhat compact texture, which forms veins in a slaty rock near the Welsh Pool in Montgomeryshire. When freed from all adhering pieces of slate and quartz, the feldspar is ground to a fine powder, and 27 parts of it are mixed with 18 of borax, 4 of Lynn sand, 3 of nitre, 3 of soda, and 3 of Cornwall china-clay. This mixture is melted into a frit, and ground to a fine powder, 3 parts of calcined borax being added previously to the grinding.

This new glaze has been examined by competent artists in London appointed by the Society, and highly approved of. They found that, from being softer than that used by the French manufacturers, it incorporates more completely with the colours, and renders them perfectly firm; whereas every artist knows that colours laid on French porcelain are extremely apt to chip off, crackle, and flake, if it is necessary to make them pass the fire a second time.

7. *Chinese Method of making Sheet-Lead, and its Application to the making of Zinc-Plates for Galvanic Experiments.*

The method of making sheet-lead employed by the Chinese has not, so far as we know, been described in this country. The following notice of it we owe to our ingenious friend and correspondent Mr Waddell, who, during his residence in China, obtained much information respecting the arts of that singular country. The operation is carried on by two men. One is seated

* Abridged from the *Transactions of the Society of Arts*, vol. xxxviii. p. 42.

on the floor, with a large flat stone before him, and with a moveable flat stone-stand at his side. His fellow-workman stands beside him with a crucible filled with melted lead, and having poured a certain quantity upon the stone, the other lifts the moveable stone, and, dashing it on the fluid lead, presses it out into a flat and thin plate, which he instantly removes from the stone. A second quantity of lead is poured in a similar manner, and a similar plate formed, the process being carried on with singular rapidity. The rough edges of the plates are then cut off, and they are soldered together for use.

Mr Waddell has applied this method with great success to the formation of thin plates of zinc for galvanic purposes; and we have now before us some of those made in this manner. One of them is about the 75th part of an inch thick, and is not only smooth on its surface, but remarkably uniform in its thickness.

8. *Account of a New Stain for Wood, and a Yellow Dye for Cloth.* By John Hill, Esq.*

The new stain proposed by Mr Hill consists of a decoction of walnut or hickory bark, with a small quantity of alum dissolved in it, in order to give permanency to the colour. Wood of a white colour receives from the application of this liquor a beautiful yellow tinge, which is not liable to fade. It is particularly adapted for furniture made of maple, particularly that kind of it which is called birds-eye, and which is commonly prepared by scorching its surface over a quick fire. The application of the walnut dye gives a lustre even to the darkest shades, while to the paler and fainter ones it adds a somewhat greenish hue, and to the whiter parts various tints of yellow. After applying this stain to cherry and apple wood, the wood should be slightly reddened with a tincture of some red dye whose colour is not liable to fade. A handsome dye is thus given to it, which does not hide the grain, and which becomes still more beautiful as the wood grows darker by age.

"Walnut bark," says Mr Hill, "makes the most permanent yellow dye for dyeing cloth of any of the vegetable substances used in this country, for that purpose, with which I am acquaint-

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* Abridged from Silliman's American Journal of Science, Vol. ii. p. 166.

ed. Care should be taken that the dye be not too much concentrated: When this happens, the colour is far less bright and delicate, and approaches nearer to orange. It is hardly necessary to add, that the dye should be boiled, and kept in a brass, or some other vessel, into the composition of which iron does not enter."

9. *Description of the improved Patent Gas Meter, by* Mr John Malam.

The object of this ingenious instrument is to exhibit upon a dial-plate, the quantity of gas which passes through a tube in its progress to the burners. It is represented in Plate I. Fig. 15. where *a* is the pipe through which the gas passes that is to be measured; *b* an air tight vessel, like bellows, with the upper flap rising or falling upon a joint or hinge, and constructed of leather or cloth, protected against the chemical action of the gas.

From this vessel the gas escapes through the aperture *c*, into the outer case *d d*, and thence through the exit-pipe *e*, to the burners. The aperture *c*, is partially closed by the flat plate *f* suspended or swinging upon the rod *g*, and accommodating itself to the descent of the flap.

When equal quantities of gas pass along, in the direction *a*, *f*, *b*, *c*, *d*, *e*, in equal spaces of time, which is generally the case, the quantity of gas will be indicated by the clock movement shewn in the upper part of the figure, provided the clock always stops with the supply of gas, and goes again when the supply recommences; for effecting which, there is a particular contrivance, which shall be afterwards described. The clock movement in the cylindrical box *l*, supported and fixed upon legs *m m*, gives motion to an axle carrying a small excentric wheel, or crank *n*, in order to raise the lever *o*, which has its fulcrum on the axle of the wheel *q*, and rests upon the pheriphery of the excentric wheel. The lever being thus raised, a small spring catch *p*, attached to it, takes into the teeth of the wheel *q*, and when the lever again descends, the catch drives the wheel round a short way. Another spring *r*, holds the wheel as the lever again rises; and, in this manner, by many revolutions of the excentric wheel *n*, raising and lowering the lever *o*, the wheel *q*

is driven entirely round. A pinion upon the axle of *q*, works in the wheel *s*, which carries the index round a dial-plate, and thus registers the quantity of gas which has passed uniformly through the aperture *c*.

Should the pressure of the gas, however, not be uniform, the flap of the vessel *b* will be raised or depressed accordingly, as indicated by the dotted line When this happens, the connecting rods *h*, *i*, *k*, will raise or depress the lever *o*, so as to make it move through a greater or less arch, and consequently drive forward a greater or less number of the teeth of the wheel *q*. Upon the arm *k*, is a stop *t*, which, when the flap of *b* descends and contracts the passage of the gas, will, by the connecting arms, *h*, *i*, *k*, be raised so high as to prevent the lever from being acted upon by the excentric wheel during a part of its revolution; consequently, the arch described by the lever *o*, will be smaller, and the progress of *q* and *s* diminished: but when the flap of the vessel *b*, is raised, and enlarges the passage for the gas, then the stop *t* will be brought sufficiently low to enable the lever *o* to be acted upon by the periphery of the excentric wheel during the whole revolution; in consequence of which, the arch described by the lever *o*, will be greater, and the progress of the wheels *q* and *s* increased. A nut *v*, having a right and left screw, is employed to adjust the length of the rod *k*.

For the purpose of stopping the clock movement, when the supply of gas is stopped, a paul lever *u* rises with the rod *k*, for the purpose of locking the excentric wheel. In order to stop the passage of gas when the clock movement requires winding up, a pinion upon the axis of the fusee works in the dotted toothed arch *w w*.

The operation of winding up carries the rack back; but, as the movement goes down, the rack advances, by which a tooth *x*, upon its axle, presses upon the short end of the lever *y*, which it raises, and causes to lift the rod *k*, at the same time, making the rod *h*, press down the flap of *b*, in order to bring the aperture *c* in contact with the plate *f*, and thus obstruct completely the passage of the gas *.

* See the *London Journal of Arts*, No. viii. p. 81.

10. *On the application of Animal Empyreumatic Oil to the manufacture of Prussian Blue.—By* M. Haenle.

In attempting to render useful the empyreumatic oil produced in the manufacture of the muriate of ammonia, M. Haenle has obtained with this oil a lixivium for the preparation of Prussian blue, as rich in colouring matter as that made with horns or with blood. It produces a blue which is neither less beautiful nor less lively. For this purpose, M. Haenle reduces the animal oil into carbon, and reddens this carbon with an alkali. In this way, says he, chemists may, by means of the empyreumatic animal oil, procure, in a short time, and without being incommoded with the least smell, a prussiate of potash fit for a re-agent. To do this, a Hessian crucible, holding from 8 to 16 oz. is filled half full with animal oil, and is placed among burning coals. As soon as the oil boils, it is set on fire, and the crucible is taken out of the furnace, and placed under the chimney. In proportion as the oil consumes, more is introduced into the crucible; and, after all is burnt, the tarry product is calcined, till there rises from it a brown smoke, and till a part of it, put upon a cold body, hardens instantaneously, and presents the appearance of a porous and friable body without odour.—*Annal. Gen. des Sciences Physiques.*

11. *On the Discoloration and Porosity of Coral Ornaments, and the method of Preventing it.—By* J. J. Virey.

It has been long known, that necklaces, bracelets, and ear-rings of coral, undergo, after being worn, a very remarkable change, and become extremely white and porous. Jewellers have no other remedy for this deterioration, than to remove the upper stratum of coral, till they come to a depth where no alteration had been produced.

This change had been ascribed to the action of air and of light; but this was found by experiment not to have been the case: and a discoloration never took place, unless when the coral had actually been worn as an ornament, in which case it has sometimes been completely whitened, when used only two or three times upon the naked skin, and in heated apartments. M. Virey, therefore, very properly ascribes the discoloration and

porosity of the coral to the action of a particular acid which exists in the moisture of the body. According to the analysis of Thenard the acetic, according to Berzelius the lactic, and according to Berthollet the phosphoric acid, is found in it under particular circumstances.

In order to prevent this deterioration of coral, when used for the purposes of jewellery, M. Virey remarks, that it will be sufficient to impregnate it with a fat body, which will defend it from the immediate action of weak acids; and, for this purpose, he recommends that the coral should be digested in warm oil, or melted wax, so as to enable it to resist the action of the acid to which it is exposed.—*Journal de Pharmacie*, Avril 1821, No. IV. p. 193.

ART. XIX.—*Account of a Chinese Lusus Naturæ.* By JOHN LIVINGSTONE, Surgeon to the British Factory, China. Communicated by the Author.

IN Europe, monsters never fail to excite much public attention; they readily obtain a place in museums and the cabinets of the curious: and even slight deviations from nature, such as a finger or a toe, more or less, have been the subject of elaborate memoirs, perhaps in many respects disproportionate to their real importance. In China the case is quite otherwise. We know of no such collections. I understand from Dr Morrison that their books are silent on this subject; and the very extraordinary and interesting monster which I am about to describe, was born only two days journey from Canton, about sixteen years ago; has been exhibited at Canton, and all around, ever since; yet, as far as my inquiries have extended, no account of this lusus naturæ has hitherto been drawn up, or has come to the knowledge of any European.

When I was first informed that a monster was to be seen in a temporary inclosure near St Agostinho's Church, Macao, I lost no time in attempting to gratify my curiosity; but I learned that the monster was then unwell, and had retired to rest. I then formed the resolution of having him brought to my house, for the double purpose of more deliberate observation, and ha-

ving at the same time a correct model made under my own eye; but aware that the only good artist then in Macao was employed, I deferred giving my orders for a few days; in the mean time, the monster unexpectedly left Macao.

However, the modeller had made such careful observations of the subject, that he informed me he could make an exact representation of what he saw. He has succeeded so well, that I am assured by many friends who had carefully examined the original, that the model is wonderfully exact;—a few unimportant exceptions shall be pointed out in the order of my description. I have spared no pains in collecting information from every quarter. I have had the advantage of receiving accounts from a great many intelligent friends, among whom I have the pleasure to mention three medical gentlemen of this place. All their accounts agree surprisingly well. The model has been shewn to many of them, and my account read, with both of which they are entirely satisfied,—so I am persuaded that my own observations could not have added much either to the value or variety of those which I have been so fortunate as to receive from others.

A-ke was born sixteen years ago, in the district of Yun-lang-yuen, with another male child of nearly the same size united to the pit of his stomach by the neck, as if his brother had plunged its head into his breast. The skin of the principal here joins that of the upper part of the neck of the parasite, quite regularly and smoothly, excepting the superficial bloodvessels, which appear somewhat turgid. The sufferings of the mother were so great, that she survived the birth of this monster only two days.

Since that time, the parasite has not much increased in size *, and at present is not much larger than new-born infants usually are; but the bones are completely formed. The shoulder bones are remarkably prominent. Here the model is faulty, since it represents the roundness of infancy; but all this plumpness has disappeared from the original, where bones seem only to be co-

* I have the authority of Lieut.-General Wood for stating, that a careful admeasurement of the parasite was made at his request;—the trunk and neck measured about eleven inches, and the longest limb thirteen inches, making the extreme length two feet. This accords sufficiently well with the size I have mentioned; but as the modellers in China do not work by any scale, it would be useless to deduce any *exact* measurement of the whole figure by knowing a part.

vered with skin. The hips of the model are too prominent. The manner in which the thighs appear is quite happy; but the feet, particularly the left, are not sufficiently clubbed. In the original, generally the feet and toes are less perfect than in the model. The toes adhere, and one or two are wanting.

The attachment of the neck of the parasite to the chest of the principal, admits of a semirotatory motion. The natural position of the bellies is towards each other; but A-ke can turn his brother so far round that he can bring either side towards his own belly. He also shews that his brother's arms can be moved freely. The thighs and legs remain stiffly bent, as represented in the model: the thigh being anchylosed with the *ossa innominata* above, and the *tibiæ* below. In sciagraphia, genitalia nimis perfecta apparent; quoniam in archetypo, testium vestigium nullum, scrotique exiguum tantum, videndum sit. At penis proportionaliter crassus est; et præputium glandem semivelat. Tentigo interdum observatur; quo tempore fluidum viscidum ex urethra stillat, quapropter Sinenses semen copiose secerni credunt. Renes officia rite perficiunt; anus deest.

A-ke is now about four feet ten inches high, of a feeble frame and sickly appearance; but excepting the encumbrance above described, he is in all respects perfectly formed. He appears to be sufficiently conversible and intelligent, and says that he has the same feeling of pain, if any part of his brother's body is hurt, as if it was the same part of his own body: even the slightest touch which would be perceptible, if applied to his own person, is equally perceptible if applied to his brother. This statement was most satisfactorily confirmed by an ingenious medical gentleman, who, observing A-ke's attention to be fully employed, and his head turned away in a contrary direction, pinched quickly the hip of the parasite; A-ke instantly struck the same part of his own person, just as if that had been the pinched place.

Formerly he had reason to imagine, from certain obscure motions which he perceived within his brother, when he was himself in pain, that all their feelings were reciprocal; but for some time past he has not been sensible of this, nisi micturus sit. Frater ejus nunquam eodem tempore, seu urgente naturâ, seu

curiositati adstantium satisfaciendi causa, urinam reddere deficit.

A-ke's respiration is never perfectly free: on the contrary, it is commonly laborious, and on the slightest exertion, such as walking to a little distance, ascending a flight of steps, or the like, he breathes quickly, and with difficulty. To relieve this he supports the parasite with his hands; but to obtain any considerable degree of ease, a recumbent posture is necessary. His pulse is commonly quick and small. Mr Gomez felt distinctly the pulsation of the carotids in the neck of the parasite; it was feeble. He also examined carefully the pulse at the wrists; it was very slow, *(valde lente)*.

The usual temperature of both is natural. A-ke wears an unusual quantity of clothes, yet he never appears to perspire, even in the warmest weather. His usual gait is unsteady and feeble; when he walks up or down stairs, he supports himself with one hand, and his brother with the other, and brings both his feet upon the same step, before he attempts to advance another foot.

When in his best state of health, he informed Mr Gomez his appetite was so good, that he could take as much food as any three of his age; at present his health in general is much impaired. He complains of weakness of stomach, loss of appetite, defective and painful digestion; so it is commonly thought that he cannot live long. His countenance is sallow, and more emaciated than it appears in the model.

A-ke's father is one of the poorest class of husbandmen. He has been content to hire his son for five Spanish dollars a month to the man, who has for his trouble all the profits of the exhibition. Ten cash (less than a penny Sterling) is the price of admittance into the inclosure, which they make in public places. He walks to private houses; the parasite appearing while going through the streets like a tumor under his clothes. On these occasions the exhibitor is content to receive whatever is given. He commonly gets half a dollar or a dollar. The concern does not appear to be profitable.

Having stated all the circumstances of this wonderful and most interesting case, as fully as they have come to my knowledge, I might be excused from making any observations,—the

field is ample, and no doubt a variety of ingenious opinions will be formed. I think, however, you will be desirous to have my reflections on some points. I shall therefore mention a few.

It will probably be admitted, that as the quantity of nourishment which the parasite derives from the principal system, is only sufficient to preserve life, without adding to the bulk of its parts, it receives blood only from small arteries, perhaps from the branches of the mammary arteries, where they freely enosculate with the large branches of the epigastrics, forming arteries which may either immediately anastomose with those of the parasite, and supply its veins and heart with blood, sufficient to support a species of circulation, similar to that of the *fœtus in utero:* the principal supplying the place of the *placenta*, or the blood may be returned to the principal, by a set of veins peculiar to the parasitic state of existence. It is highly probable that the entire pulmonary system is wanting, or in a state of complete torpor; and from the flaccid appearance of the abdomen, we can scarcely doubt but the *chylopoictic viscera* are in a similar state.

Considering the Chinese account of the seminal secretion as founded in error, the parasite can only be regarded as having the kidneys in an efficient state, besides the circulation of the blood, and absorbents. This state seems to admit of no other function.

This view of our subject accords sufficiently well with that theory of Monstrous Productions, which supposes that two distinct embryos had coalesced by some accidental circumstance, which may have caused the amnions of each to adhere; and controverts an opinion which at one time had many advocates, respecting the use of the *liquor amnii.* It may be conjectured, on the same view, that the great sympathetic nerve of A-ke supplies the urinary and genital systems, and that the nerves of his skin are diffused over that of his brother also. All this will require that our notions of the nervous system shall be considerably modified, before we can be enabled to account for the few, but decisive facts which belong to this part of our subject. To account for these, on commonly received principles, it will be necessary to suppose that the monster had the same conformation in the primordial germ. This conjecture removes some of our difficulties

It explains how the brain of A-ke is in all respects a *sensorium commune* to both. That the parasite is therefore only a duplicate of the principal, is not more difficult to be imagined than a supplementary finger or toe. Here, however, our field expands into a wilderness, into which it would be unsafe to enter without a guide. I shall therefore resign the task into the hands of more adventurous discoverers.

MACAO, 8*th December* 1820.

ART. XX.—*History of the Magnetic Observations said to have been made at Zwanenburg* *. In a Letter to Dr BREWSTER from M. G. MOLL, Professor of Mathematics and Natural Philosophy in the University of Utrecht, and Member of the Royal Institute of the Netherlands.

SIR,

IN the last Number of your very valuable Journal, I find a table of observations inserted, on the diurnal variations of the magnetic needle, from 1775 to 1780, which are stated to have been made *at Zwanenburg in Holland*, whilst you were unacquainted with the name of the observer, and the nature of his apparatus. Give me leave to say, that these observations, which are indeed very valuable, were *not* made at Zwanenburg, but in a village at no great distance from that place, called Sparendam. I am not aware that observations on the magnetic needle were ever made at Zwanenburg for any length of time, although the barometer and thermometer have been observed there with great care ever since 1743. You may find these observations in the Transactions of the Haarlem Society; and a paper has been given in on that subject to the Institute of the Netherlands by Professor Van Swinden, which is printed in the 1st volume of the Memoirs of that Society. Your correspondent Mr Rumker could not do otherwise than suppose that the magnetic observations alluded to were made at Zwanenburg. They are represented as made there even in the volumes of the Transactions of the Haarlem Society, in which they are printed, and from that

* See this *Journal*, vol. iv. p. 348.

work Mr Rumker or Colonel Beaufoy might have taken them. It is however certain, that these magnetic observations were made at Sparendam by one Dr Engelman, Inspector of the Hydraulic works in the district of Rhineland. Dr Engelman began his observations in 1770, and died in 1782. The apparatus he made use of is now in the possession of Professor Van Swinden at Amsterdam. This gentleman gave some account of these observations in his *Recherches sur les aiguilles aimantées*, in tom. viii. of the *Mémoires présentés à l'Académie Royale des Sciences à Paris*, in which volume an abstract is also found of the very valuable observations which Professor Van Swinden made at Franeker in Friesland, during a long series of years. You may ascertain very easily the correctness of the statement which I now have the honour to make, by referring to the books pointed out. You will find, by inspecting the volume of the *Mémoires des Savans Etrangers*, before alluded to, that the observations which you republished, were made by Dr Engelman in the garden of the house which he occupied at Sparendam in his official capacity. The Latitude of Sparendam is 52° 24′ 55″; Longitude 2° 20′ 29″ East of Paris observatory. The Latitude of Zwanenburg is 52° 23′ 10″; Longitude 2° 24′ 43″ East of Paris Observatory. I am, Sir, &c.

G. Moll.

Utrecht, 30*th April* 1821.

Art. XXI.—*On the Rocky Mountain Sheep of the Americans.* By Professor Jameson *.

The Spanish missionaries in California, so early as 1697, make particular mention of a "remarkable species of sheep" as occurring in that country; and it is again noticed by Venegas, in his History of California. Lewis and Clarke also heard of it, and obtained some skins from the Rocky Mountains. I now present to the Society a skin of this animal, which was sent from Hudson's Bay, by Mr Auld, formerly of that country, and who obtained it from the Rocky Mountains. It appears to be the

* Read at a meeting of the Wernerian Natural History Society, and published in the Memoirs, vol. iii.

Rocky Mountain Sheep of the Americans. A simple inspection of the specimen before us, proves that it cannot be a species of the genus Ovis; and the form of the horns, and shape of the body, will not allow of its being placed with the Capræ or Goats; while its form, beard and fur, remove it from the genus Antelope. We are of opinion, that it forms a species of a genus intermediate between the Antelope and Goat. On examining the fleece, I was particularly struck with its uncommon fineness; and it occurred to me, that an animal inhabiting the temperate regions of the Rocky Mountains, with so valuable a fleece, might be easily procured, and readily introduced into this country, and form a valuable addition to our wool-bearing animals. Strongly impressed with this view, I now beg leave to suggest to the Society, providing they agree with me in opinion as to the value of this animal, to take steps for procuring live specimens from America, in order to make the experiment of introducing it into Scotland.

The Society having taken this proposal into consideration, appointed a committee of its members to consult with the Directors of the Highland Society of Scotland, on this important proposal; and also to request Mr Thomas Laurie, who has long been distinguished for his intimate acquaintance with rural affairs, to report as to the value of the wool, &c.

The following is the report of Mr Laurie:

" The skin submitted to us, is, in the minutes of the Society, denominated that of " The Rocky Mountain Sheep;" and, from the wool with which it is covered, it may certainly be considered as nearly allied to that genus of quadrupeds, though, had it wanted this woolly covering, we would probably have been inclined to consider it as more allied to the goat. The general figure of this skin is very different from that of any sheep's skin I have ever seen. The difference is perhaps most remarkable in the length and figure of the neck, which, in no slight degree, resembles that of a thorough bred horse. The general structure of the head, externally viewed, does not appear to vary from that of other sheep, more than might be ascribed to accidental circumstances. To this remark, however, the horns form a remarkable exception. Their position is very different from what is observed in the common sheep. Their

curvature is also different,—circumstances which deserve more particular notice, on account of their being connected with other important diversities of character: These are the smoothness of the horns, and their circular, or rather conical shape,—two particulars in which they differ from the horns of every species of sheep with which either history or observation has made us acquainted. The blackness of the horns, compared with the whiteness of the wool, may also be mentioned, though, in other circumstances, unworthy of notice. The legs, too, of this skin, are covered with longer and coarser hair than what is to be found on those of the common sheep. The horns resemble those of a common goat, more than of a sheep, in regard to position, colour, and texture. But the goats horns are flat on the under part, or that next the neck, so as to form the side of a pyramid. In other respects they are conical. The horns of the Rocky Mountain Sheep are completely conical, and in shape resemble the horns of an ox more than those of either a goat or any of the varieties of sheep.

" There is another circumstance of apparent resemblance to the goat, which may be noticed. The skin exhibited has a ridge of hair along the back, considerably longer than the general covering, which is continued up the neck, in the form of a mane, thicker and longer than that on the back. It has also a thick long beard, and a space on each quarter covered with long shaggy hair. In these particulars there is a resemblance to the male of the common goat; and I think it probable the skin belongs to the male sex. In the length of the neck, compared with that of the body, there is also a resemblance to the common goat. But, in all these points of resemblance, there are specific differences, which a comparison would best illustrate.

" The wool forming the principal covering of the skin, is a strong reason for not classing the animal with the family of goats. It is no doubt true, that the goat of the East yields a fur in many respects resembling wool; and it may be difficult, in some cases, to distinguish between hair and wool, especially from small specimens. But, in judging from any considerable quantity, such as the covering of a whole skin, there would be little difficulty in determining whether the substance should be called hair or wool; and, so far as I know, there is no good authority

for any species of goat ever having been found with a covering wholly or chiefly of wool.

" It may be unnecessary to enlarge farther upon the classification of the animal, as the question cannot perhaps be satisfactorily decided, without the possession of a living specimen.

" The skin seems to be that of a full grown animal. A number of observations might be offered in illustration of this opinion. But it may suffice to state, that the horns and general aspect of the head, have all the appearances of maturity. The teeth, in particular, are evidently fully grown, and such as are observed in a sheep upwards of three years old. Four of them, on one side, are more or less broken, which may have occurred either from accident or age.

" The wool, which forms the chief covering of the skin, is fully an inch and a half long, and is of the very finest quality. It is unlike the fleece of the common sheep, which contains a variety of different kinds, suitable to the fabrication of articles very dissimilar in their nature, and requires much care to distribute them in their proper order. The fleece under consideration is wholly fine. That on the fore part of the skin has all the apparent qualities of fine *wool.* On the back part, it very much resembles *cotton.* The whole fleece is much mixed with hairs; and, on those parts where the hairs are long and pendant, there is almost no wool.

" The wool, if separated from the hairs, would, I think, be adapted for the finest purposes of manufacture. But, in its present state, it could not be so applied, though many of the hairs would fly off in the manufacturing processes. It is, however, highly probable, that, by a careful selection of breeding stock, the hairs might, in a great measure, or perhaps entirely disappear in the course of a very few generations. It has always been observed, that where sheep have been neglected their wool has been comparatively coarse; and wherever they have been properly treated, and due advantage taken of the accidental finer varieties, the quality of their wool has been proportionally ameliorated. Indeed the improvement in the qualities of wool has uniformly been marked as keeping pace with the progress of arts and civilization. I am, therefore, of opinion, that the wool of the Rocky Mountain Sheep would soon become a great ac-

quisition to the manufacturers of this country, were the animal which yields it to experience the judicious treatment of many British flocks; and there can be no doubt, that such an experiment would be well worth trying. Under this impression, I cannot help expressing a wish, that the Society, to whose consideration these remarks are submitted, would exert their influence for accomplishing an object which may prove of national importance.

"At the same time, it is proper to observe, that sheep are not to be considered as valuable for their fleece alone. They merit attention as furnishing *food* as well as *clothing* to man, and any particular race is of value only in so far as these important objects are combined. How far the Rocky Mountain Sheep might prove useful as furnishing food, I have had no opportunities of ascertaining. As to the value of the wool, if obtained in purity, there seems no room for doubt; and I may state, that I have shewn specimens to different wool-dealers, all of whom expressed their admiration of their quality, and even an anxiety to purchase. From these specimens, however, it may be fair to add, the hairs had been in a great measure extracted.

"It may be mentioned, in conclusion, that it cannot be known from the skin exhibited, whether or not the Rocky Mountain Sheep produces what dealers would call *long wool*. The longest observed on the skin is scarcely exceeding two inches, being about one-half the usual length of the full-grown fleeces of the mountain sheep of Great Britain, or what is called the carding and clothing wool, which is even much shorter than the comb-sort used for worsted stuffs, &c. The comparative shortness, however, of the wool under consideration, proves nothing. Sheep cast their wool annually, if not shorn, and a new coat springs up. This generally takes place in this country about the month of June. If, therefore, the animal which produced the wool under consideration, was killed soon after casting its old wool, the new wool would not be at its full growth. This too, is a point which could best be determined by procuring living specimens of the animal, and observing their habits and changes."

Professor Jameson's proposal having been submitted to the

Directors of the Highland Society, they expressed their willingness to co-operate, and appointed a Committee to confer with a Committee of the Wernerian Society on the business; and it is in contemplation to communicate with the Right Honourable the Earl of Dalhousie (a Vice-President of the Society, and now Governor-General of Canada), and request the good offices of that patriotic nobleman towards the sending home of living specimens of the animal.

Art. XXII.—*Account of a New Optical Instrument, which combines the properties of a Compound Microscope, Camera Obscura, Camera Lucida, and Diagonal Mirror.* By Alexander Waddell, Esq.

My Dear Sir,

Since I furnished you with a drawing and description of an optical instrument I constructed about eight years since, which you inserted under the Article Microscope of the *Edinburgh Encyclopædia*, I have lately adopted a different mode in the construction and application of it, which, I think, combines certain advantages that the former did not possess. I therefore send you a drawing and description of it, lest you may think them worthy of a place in the Edinburgh Philosophical Journal.

Fig. 3. of Plate IV. represents the instrument under its improved construction. The body is formed of two hollow hemispheres of brass screwed together, within which is placed a metallic reflector, at an angle of 45° with the tubes of the instrument, which are screwed into the upper and front sides of the hollow ball of brass, the diameter of which is about four inches. The instrument is represented fitted with a right-angled triangular prism, placed at the outer end of the horizontal tube or tubes, in order to correct the position of the objects which, although erect when viewed without it, would otherwise be reversed. The object-glass of this instrument is formed of two lenses, each of double the focal distance required, placed at the points where the tubes are fixed on the top and front of the ball; and the eye-piece is of the usual construction in telescopes, and has a compound eye-glass.

The instrument is represented in Fig. 3. as resting on a spherical hollow in a flat stand, which completely supplies the place of a universal joint, as the instrument can be turned in any direction, the weight of the metallic reflector and brass ball rendering it perfectly steady, even when the vertical tube is in a horizontal position.

The purposes to which I have applied this instrument, are those of a Camera Obscura, Camera Lucida, Diagonal Mirror, and Compound Microscope. When used as a Camera Obscura, to assist in taking views from nature, or in drawing any other subject, a micrometer, divided into squares, is placed at the field-bar of the instrument, and the drawing-paper being divided into corresponding squares of any dimensions, the objects seen in the field of view of the instrument, can, by a person at all practised in drawing, be delineated with the greatest truth, and on any required scale; and as the instrument has a small magnifying power, distant objects can be seen by any eye with the greatest distinctness. When used as a Camera Lucida, without the micrometer, the instrument is placed on its side upon an elevated stand, with triangular feet, as seen in Fig. 4., and the prism before mentioned is removed from the outer end of the horizontal tube, now foreshortened, and pointing towards you, and placed on the end of the vertical tube, now also in a horizontal position, close by the eye-glass; and as it is open on the under side, as in the prism of the camera lucida, by a similar adjustment of the eye, the picture seen in the instrument will appear to be painted on the table below, and the outline of it may be drawn on paper, with the same precision as with that instrument; for in both positions of the instrument above described, the objects seen are neither inverted nor reversed, although, from its peculiar construction, they must necessarily be received into the instrument, from the observer's left hand side. When used as a Diagonal Mirror, the prism that displaced the eye-aperture may be removed, and the aperture again fixed to the eye-piece, and the instrument placed in its former upright position upon the stand represented at Fig. 3. When any print or tinted view is properly illuminated, and placed in a position perpendicular to the axis of the instrument, then, by an adjustment of the sliding-tubes to the eye, as in a common telescope, the objects of the illuminated

picture will be seen more distinctly than with the natural eye, and greatly magnified; and the size of the objects, and extent of the field of view, will be regulated by the distance of the instrument from the picture. And when the instrument is used as a Compound Microscope, the magnifiers necessary are screwed into the end of the horizontal tube described at Fig. 1., the outer end of which is left perfectly smooth, in order to receive another short sliding-tube, fitted as a stage, with spiral screws, for admitting sliders of any thickness, with transparent objects. When opaque objects are to be examined by this microscope, they are placed on a stage, properly illuminated; and the instrument being placed on the spherical hollow stand, first described, at or about the focal distance of the glasses of the instrument from the object to be viewed, distinct vision may be quickly obtained, without any adjustment of the tubes of the instrument, by merely moving the flat stand on which it is placed gently to or from the object to be viewed. It will be seen from the construction of this instrument, that its greatest magnifying power as a microscope, must be when all the tubes are fully drawn out, but that the power may be increased or diminished to a certain degree at pleasure, by shoving out or in the said tubes, without any change being made on the glasses of the instrument.

It may be objected to this instrument, that a considerable portion of light must be lost by the refractions and reflections necessary to produce the effects described. I have not, however, found in practice that any material disadvantage arises therefrom, as I think the largeness of the apertures made use of admits a sufficiency of light to obviate this defect; and I have not been able to discover, particularly in microscopic researches, that the instrument possesses any disadvantages in regard to distinctness of vision.

As this instrument, with the spherical ball of brass and metallic reflector within the same, is so heavy as to make it not sufficiently portable for carrying abroad, to assist in taking views from nature, I have devised a mode to remedy this, by rendering the vertical tube or tubes of the instrument described under Fig. 1. fit for the purpose. When this tube is unscrewed from the upper part of the brass ball, it will be seen, that one of the

object-glasses of the instrument is attached to it, and that by removing the other object-glass from the inner end of the horizontal tube in front of the instrument, and placing it in the wider part of a conical mouth-piece of brass, which screws into the object-end of said vertical tube, as represented under Fig. 3. both object-glasses are brought near to each other, and it again becomes an astronomical telescope, with a small magnifying power. If to this conical mouth-piece of brass be affixed one of the double right-angled triangular prisms of one piece of glass, with its two reflecting surfaces placed at right angles, constructed by me some time since, and drawn and described under the article Microscope of the Edinburgh Encyclopædia before alluded to, then, by the use of a microscope placed at the field-bar as before described, it is again fitted for the purposes of a camera obscura, when placed in a vertical position on a portable stand, also represented under Fig. 3. If this instrument, instead of the vertical position it here appears in, be placed in a horizontal one, and the double prism removed from the object, and affixed at the eye-end of the instrument, then it becomes fitted for the purposes of a camera lucida, because the said double prism is left uncovered, both above and below, as in the former case described. And if to the extremity of the said conical mouth-piece be affixed a smooth tube, with additional magnifiers as before described, then the instrument, if so required, becomes fitted for the purposes of a compound microscope.

From the various distances at which the glasses of the instrument first described are placed, it is not easy to ascertain its magnifying power as a microscope, by the common rule of calculation. But by the addition of a compound magnifier of half an inch focus to its glasses, as an astronomical telescope, I have found the apparent magnified surface of the field of view, when at the same distance from the eye that the image of the object painted within the instrument was from the object itself, and when the magnified appearance of the object filled the whole of that field, to be, when compared with the real size of the object viewed, as 1600 to 1. ALEX. WADDELL.

HERMITAGE HILL, 7th May 1821.

To Dr Brewster.

Art. XXIII.—*Account of the Explosion of a Steam-Boiler at Lochrin Distillery*. By Robert Stevenson, Esq. F. R. S. E. Civil Engineer.

The alarming accident which happened at Lochrin Distillery about five o'clock in the afternoon of the 2d of April last, by the explosion of a large steam-boiler on the high pressure principle, having created a very considerable sensation in the public mind, Mr Adie optician and I visited the spot on the following day, and were kindly received by Mr Haig, the proprietor of the works, who freely communicated to us every information on the subject.

It would be foreign to the object of this notice, to enter into any detail regarding the extent of Lochrin Distillery; but I cannot omit observing how important its operations must be in a public point of view, especially to the agriculturist, when it is considered, that, in the form of duties to Government alone, the proprietors sometimes pay *Fifteen thousand pounds Sterling a-week*, for spirits distilled from grain. Every circumstance, therefore, connected with operations of such magnitude, becomes an object of general concern.

A proposition having been made for boiling the large stills of Lochrin by means of steam at a high pressure, to be conducted through pipes into these vessels, as more economical and convenient for the works, than the common furnaces,—an apparatus was manufactured by the workmen belonging to the distillery, in which no expence seems to have been spared for making the steam-boiler as complete and effective as possible. The boiler and its appurtenances began to work about the 21st of March last; but had only been in operation about twelve days, when something connected with the mercurial-gauge for measuring the intensity or pressure of the steam, was observed to be out of order. Before the engineer could be got to examine and repair it, an explosion took place, attended by circumstances which indicate the sudden production of a force uncontrollably great.

The boiler measured no less than about 37 feet in length, 3 feet in breadth at the bottom, 2 feet immediately under the top, and

about 4 feet in height; and the bottom, forming a semicircle, rose into the body of the boiler. Its cross-section was of a crescent form, as will be seen by referring to Plate I. Fig. 17., a construction adopted with a view to the more ready and beneficial circulation of the heat of the furnace. The whole weight of the boiler is said to have been about 9 tons; of which the top and sides were estimated to weigh about 7 tons. This large proportion of 7 tons weight was torn from the bottom by the expansive force, and thrown up with such amazing impetus, that it dashed aside its arched covering of brick-work, penetrated the roof of the boiler-house, and, according to the estimate of those who witnessed the scene, rose into the atmosphere to the height of not less than 70 feet before it began to descend. On the south, the boiler-house was flanked by other buildings; while it was free on the north. Owing to this circumstance, the projected mass naturally received an inclination to the northward, and, describing an arch in its passage through the air, it alighted on the roof of the great mash-house of the distillery, situate at the distance of 150 feet from the boiler-house, and in its fall carried every thing before it. Even the floor of the mash-house was broken up, and one side of a large circular mashing-vat of cast-iron was crushed in pieces.

To illustrate the expansive force still farther, we may observe, that the boiler was constructed of malleable iron plates, three-eighths of an inch in thickness, and only 8 inches in breadth. With a view to bind and strengthen the cross-section of the boiler, it was set upon thirty-six bars of cast-iron, measuring 6 inches in depth, by 2½ inches in thickness, forming so many ties across the semicircular bottom. Notwithstanding these precautions, we see, that the top and sides of this ponderous vessel were wrested from its bottom; and, though weighing about 7 tons, as before noticed, were projected into the air about 70 feet, and fell at the distance of 150 feet. It also deserves our particular notice, that the bottom, though lifted with the top and sides at least to the height of 14 or 15 feet, was found deposited among the rubbish merely on the outside of the boiler-house; it was bent, however, from its regular semicircular

form, into an angular figure in the reverse direction; the convex having now become the concave side.

These circumstances strikingly shew the invincible power of the agents employed in such apparatus, and point out the responsibility which unavoidably attaches itself to the employment of steam at a high pressure, in a manufactory, where numerous individuals, and much valuable property, are at stake. In this case, the greatest anxiety certainly existed on the part of the proprietors, to have recourse to every proper precaution; yet an explosion took place, and two workmen who were in attendance on the boiler, lost their lives. One of the sufferers was found with his head cloven in two. The legs of the other man were severed from the body, and found in the boiler-house, while the body itself was discovered among the rubbish on the outside of the building. Among the surprising circumstances, however, which attended this disaster, it may be noticed, that comparatively little damage was done, though the premises are every where composed of inflammable matters, and crowded with people at work, all of whom escaped without injury, excepting the two unfortunate individuals mentioned.

The boiler, in the act of bursting, discharged a great quantity of steam in the air, part of which was condensed upon the upper walls of the adjoining buildings, which still appear as if they had been partially white-washed. A dreadful noise was also heard at a distance like a clap of thunder; though those engaged within the premisses do not appear to have been much alarmed by the noise of the explosion. It may be added, that the tremor produced by the concussion was distinctly felt at the distance of a mile from the Distillery.

It is now, perhaps, impossible to ascertain with certainty how this accident happened; but it deserves to be remarked, that the sides and top of the boiler were torn from the bottom horizontally, in the direction of one of the rows of rivet-holes, almost in as regular a manner as if the separation had been made with a sharp instrument. We cannot help thinking, that this boiler was pierced with a superabundance of rivet-holes. For the plates, which were only 8 inches in breadth, were made to overlap each other 4 inches, and then rivetted in such a manner, that over the whole surface of the boiler only bands or com-

partments of about 4 inches in breadth, were left without perforations. These holes being, at the same time, pierced only about one inch and a quarter apart; almost as much of the iron at the seams or joinings was, by this means, cut into rivet-holes as was left in an entire state. We may add, that if this boiler, which was made with materials of great strength, had been more judiciously put together; if fewer rivets had been employed, and if the bars across the bottom, marked letter *a* in the section, Fig. 1. Plate 17. had been rivetted and otherwise strongly connected with the horns or points of the crescent bottom, it might have resisted a much greater strain than it was calculated to sustain.

In building or constructing steam-boilers, the work should be so laid out by the artist, that the plates may *break joint*, if we may apply a technical term in masonry to this operation; or, in other words, the plates of which the boiler is to be formed should be so arranged, that the end-joint of one plate may fall into the middle of the two adjoining plates. If attention were paid to this arrangement, the plates of the top and bottom would form part of the sides, and the vessel would possess much additional strength, at the expence, perhaps, of but a little more labour. In preserving the strength of the plates, great attention should also be paid to the punching or perforation of the holes in good order, that the seams may fit each other. The punch or chisel for this purpose, should be uniformly cylindrical, or have as little taper towards the point as possible; so that the fibre or texture of the iron may not be deranged in perforating the rivet-holes. When iron is unduly stretched in this operation, it produces an effect similar to what workmen term *cold-short*; and has a direct tendency to lessen the strength of the portions of iron remaining between the holes. These holes ought also, invariably, to be pierced, so as to run in a zig-zag or alternate direction, instead of being ranged in straight lines, as is sometimes done.

To show still farther the utility of these observations, let us suppose that a horizontal section of the boiler at Lochrin contained 324 square inches of iron. After making every allowance for rivet-holes of the diameter of $\frac{7}{8}$ths of an inch, perforated at the distance of about 1 inch and $\frac{1}{8}$th apart, we find, from the

aggregate strength of these portions of iron, supposing the whole to be in a sound state, and allowing at the rate of 27 tons as the force which a square inch of good iron will sustain, that the boiler would withstand a force of about 8748 tons, before it would be torn asunder. Instead of 1 inch and ¼th, let us suppose that the holes are perforated at the distance of 2 inches apart, and we shall then find that the boiler will sustain a force equal to about 12,724 tons, or equal to 3976 tons more. On examining the section of this boiler, it will be found, that its figure is not calculated to give strength, unless the *horns* or points of the crescent had been very strongly connected by bolts or rivets, to the bars crossing the arched bottom. For it is not sufficient to set a boiler upon cast-iron bars, and make them simply to embrace it by wedging with iron at the bottom, without fixing them with rivets, or bolts; neither does it appear that cast iron is so suitable for this purpose as malleable iron.

In explaining the immediate cause of the explosion, it has been supposed, that the upper ridge of the semicircular bottom of the boiler had been allowed to get into a state of incandescence, when a jet of water from the feeding-pipe having (as is imagined) been incautiously let into the boiler, the effect of an additional supply of water in this critical state of things, was to produce a sudden and great quantity of steam, or the extrication of gases of enormous volume, by the decomposition of the water, by which the boiler, as we learn, was projected into the air like a rocket.

In the first trials of the boiler at Lochrin, though weighing upwards of nine tons, it was found to vibrate and move in its place with the force of the steam at the rate of about 60 pounds to the square inch. The pressure was then, by the express orders of Messrs Haig, reduced to 40 pounds upon the square inch, and one of the safety-valves with this load, was put under lock and key, and the charge of it given to the foreman of the works In consequence of some mismanagement, however, the pressure must obviously have been greatly increased. If we suppose the velocity of the top and sides of the boiler at the moment of the explosion, to have been at the rate of about 80 feet per second, its impetus in that case had been not less than about 720 tons. We here calculate the cast-iron bars in the usual way,

though it must be recollected that this metal, when heated, loses much of its strength. On the whole, however, it is probable that the entire impulse given by the explosive force, could not in this case have been less than 3380 tons on the area of the boiler, or about 215 pounds upon each square inch of its surface.

The working power of steam in the condensing engines upon Watt and Bolton's principle, is now usually adjusted to a pressure of from 2 to 5 pounds upon the square inch. But in Trevethick's or Woolf's high pressure engines, where there is no condensing apparatus, it is not unusual to work with upwards of 80 pounds on the square inch. The greatest precaution, therefore, in the application of this principle, becomes necessary in the management of the apparatus.

On the other hand, it may be proper to observe, that accidents like this of Lochrin, are by no means beyond the power of remedy. If proper attention were paid to the safety-valves, and to the obvious and simple indications of the mercurial gauge, and if the firemen were regular in supplying the boiler with fuel and water, the risk of explosion might with considerable certainty be avoided.

Notwithstanding the numerous improvements upon the steam-engine which are daily making, it is still a desideratum in the use of the steam-boiler to construct a safety-valve, which shall depend as little as possible upon the engine-men for the certainty of its operation. For this purpose, Mr Adie suggests, that a piece of plate-copper might be introduced into the manhole of the boiler, the strength of which should be previously so adjusted that it shall give way when the expansive force of the steam exceeds about one-half more than the pressure at which it is intended to be wrought. For the greater safety of those near the boiler, a wooden or metallic pipe might be connected with this plate or regulator, which should be made to rise 12 or 14 feet above the boiler. Although this description of safety-valve would, perhaps, when occasionally thrown off, deprive us for a time of the use of the boiler; yet the object of the greater safety of persons in its neighbourhood would be attained.

Since the preceding part of this article was read before the

Wernerian Society, on the 14th of April last, the writer of it has again visited the scene of the explosion, in company with Mr Neill, secretary to that society, Mr Bald, engineer, and Mr Gutzmer, iron-founder and engine-maker; when the circumstances of this catastrophe were again inquired into, though without being able to come to any very satisfactory result upon the immediate cause of the accident.

Upon inspecting the boiler, in order to ascertain if it had been heated to a state of incandescence, one end of the bottom bore marks of a brownish colour, such as iron generally exhibits when cooled from a state of redness, while, at the opposite extremity, ascertained to be the end of the boiler next to the furnace-door, part of a leaden plug, filling one of the rivet-holes, was found unmelted in its place. This leaden plug had been introduced with a view more effectually to guard against the very accident which we are now supposing to have happened, by the bottom of the boiler getting red-hot, and the introduction of a jet of water while it was in that state.

The circumstance of the leaden plug having been found unaltered in its place in the inside of the bottom of the boiler, seems to show that the part next to the furnace door had not been in a state of incandescence, otherwise this plug must have been melted in the interior, as it was either melted or had been broken off on the exterior side of the boiler, and disappeared. But it is possible that a quantity of water had remained in the boiler at the moment of the explosion, and that the current of air near the furnace door had been sufficient to prevent the inside part of the plug from melting. In a boiler 37 feet long, its bottom might be so distorted by the heat of the furnace, that a small quantity of water might remain at one end, while the other end was heated to redness; and this, on the introduction of water, would suddenly produce the extrication of gases sufficient, by their expansive force, to cause the explosion.

It is hardly possible to conceive that such violent and instantaneous effects could proceed from steam raised in the usual way, as there were two safety-valves in the top of the boiler, which were said to have been loaded with not more than 40 pounds to the square inch. It seems most probable, therefore, that the immediate cause of this accident, was the unduly heated

state of the end of the boiler next the feeding-pipe. This is also rendered likely, from the body of one of the unfortunate sufferers having been found near the position of this pipe after the accident, who is supposed to have been in the act of turning the cock when the explosion took place. It is, indeed, hardly possible upon any other hypothesis, to account for the production of a pressure of upwards of 200 pounds to the square inch, required for tearing the boiler asunder, and projecting about two-thirds of it into the atmosphere to the height of 70 feet.

Still it must be allowed, that a considerable degree of uncertainty hangs over the cause of this explosion. If the valves were not strangely mismanaged, how is it possible that the steam could be raised gradually to such a pressure as was necessary to produce effects equal to the most violent results from the explosion of gunpowder? On the other hand, if we suppose that the end of the boiler next to the pipe for supplying it with water had got into a state of incandescence, and that the fireman had suddenly let a quantity of water into it, we can thus account for the extrication of gases capable of producing all the phenomena which followed. The boiler, in the first or experimental trials, had vibrated in its place with a pressure of 60 pounds to the square inch, as before noticed; but the valves were now loaded only with 40 pounds to the square inch. The probability therefore is, that at the moment of the explosion, the weakest part of the boiler had given way, before the safety-valves, comparatively small, when considered in reference to a boiler 37 feet in length, could operate for its relief, from the sudden and immense pressure applied. The safety-valves, indeed, appear to have performed their office, though they were inadequate to the intended purpose. One of them was thrown out to a great height, and described a large arch, in a direction somewhat different from that of the great mass of the boiler: this iron-valve, in its fall, passed through the roof of a distant house, one of the inmates of which narrowly escaped being killed.

EDINBURGH,
June 1. 1821.

ART. XXIV.—*On Metallurgic Crystallography.* By Professor HAUSSMANN.

INTRODUCTION.—IN our investigations concerning the formation of inorganic bodies, we cannot hope to make successful discoveries in any other way, than by observing Nature actually at work in forming these bodies. And not only must we observe Nature in her own operations; we ought also to place natural bodies in such conditions as to excite and draw forth their latent powers. From effects, thus in some degree artificially produced, we may often be able to trace the path through which these bodies, as they are in their natural state, usually pass, and hence to develope the principles that regulate their formation and transformation. In these experiments, however, our conclusions are liable to uncertainty, from the consideration, that, in the case of large masses, having space and time for the operation to which they are subjected, the powers which these bodies possess, in these circumstances, are capable of producing very different effects from what they produce on a smaller scale, with space and time greatly limited. But we shall have greater dependence upon our conclusions, in proportion as the artificial conditions in which we place bodies are assimilated to those which lead naturally to the formations and changes we wish to examine. And in order to arrive at such conclusions, we shall find, that those observations which result from great metallurgical processes, are likely to be much more accurate than those resulting from small chemical experiments, though undoubtedly these last are of great importance.

By conducting our investigations in the manner stated above, we cannot fail to make the observation, that the natural powers of bodies lead often to the same result by different processes; and that some natural bodies can be made to produce the same formations by contrary processes. A formation often takes place by what is called a dry process, so exactly similar to what is produced by a wet process, as not to be distinguished the one from the other. Copper subjected to metallurgical processes, forms octaedral crystals, in the same manner as when subjected to a wet process. Crystals of arsenic acid, when produced by *sublimation*, are often similar to those which are formed from a

watery solution of that substance. The compact artificial *galena* or lead-glance, formed in melting-furnaces, cannot be distinguished from what is naturally produced in mines. *Pseudo-galena*, which is sometimes produced in melting-furnaces, bears every resemblance to that which occurs in metallic veins, except that, in the former, there may be observed a certain porousness, which is not found in the latter. We cannot, however, certainly conclude, that the specimens of galena and pseudo-galena, which occur in metallic veins and strata, are produced by one and the same process, namely, by *sublimation*. In the upper parts of the metallic vein which occurs in the mine of Andreasberg, called Catherina Neufang, there is found a compound containing arsenic, friable silver-glance, scoriaceous yellow orpiment or sulphuret of arsenic, and scoriaceous arsenical acid, which exhibits the appearance of being an igneous production, and which bears a very close affinity to some varieties of arsenical argentiferous lead, occurring in mixtures, which also are produced by heat, but which has been formed on the wet way, by a process of decomposition in the vein itself. These facts ought to make us cautious of ascribing to similar formations, uniformly one and the same cause.

Crystalline formations are by far the most remarkable of all those that proceed from inorganic bodies, because in these the operating powers act with the precise regularity of mathematical principles. Although, however, we admire this regularity of operation, and although we have made some discoveries of the mathematical connexion which subsists among the crystalline forms of various mineral substances, yet, it must be confessed, that our knowledge of the theory respecting the formation of crystals is very limited. We are strongly induced, therefore, to cultivate a more intimate knowledge of this department of science; and we trust, that, in our investigations concerning the formation of crystals, we shall derive no inconsiderable assistance from metallurgical processes. In the observations which follow, I venture to present to the public the first specimen of crystallisations, formed by metallurgical processes; and in this performance I hope to receive the more indulgence, as the train of observations which I pursue has not hitherto been entered upon.

1. *Metallic Crystallisations.*

Metallic substances, in a state of crystallisation, exhibit a much greater uniformity than other crystalline bodies. In sulphuretted, but more particularly in oxidised metals, we discover a beautiful variety of crystalline forms. According to the observations which have been hitherto made, the original form of all metals seems to be a regular octaedron; and the edge of the secondary crystalline forms, which surrounds this original form, does not possess any great extension. Mixtures do not appear to produce any change in the original form of metals; they merely regulate variously the series of secondary forms. This is evident in mixtures of antimony with silver, and of silver with mercury. Were these opinions completely established, a more profound study of mineralogy would lead to conclusions of a very important and valuable nature. From thence it might perhaps be justly inferred, that the principle of crystalline formation in those metals mentioned above, lies deeper than in those metallic substances hitherto discovered; that all metals are subjected to the same law of crystallisation, and hence that we have additional encouragement to hope for the discovery of a better method of decomposing metals. From them, also, we might be enabled to fix with much greater certainty upon that part in a substance which is characteristic and distinguishing of its nature; and sometimes we might be led to point out the method of discovering substances by chemical analysis, which have not hitherto been detected by re-agents. These conjectures are placed in a new light, by some observations which follow, with reference to metallic crystallisations produced by metallurgical processes.

a. *Iron.*—No metal in nature deserves a greater share of attention from mineralogists than iron, for none in nature is of greater importance. We are, however, so very far from having an accurate knowledge of this metal, that we are but little acquainted even with its regular external appearance. Haüy observes, that the crystallisation of native iron has the form of a regular octaedron. In the native iron which we sometimes find scattered through meteoric stones, I have observed crystals which had an octaedral appearance. This tendency in meteoric iron to the octaedral form, clearly appears also by cor-

roding with acid its polished surface. But the octaedral formation of iron can be ascertained with greater certainty, by examining some of those varieties which are produced by a metallurgical process.

Jo. Hieron. Zanichellius was the first who published accurate observations upon the octaedral crystallisation of iron. For his information he was indebted to Valisnerius, formerly Professor of Medicine in Pavia, to whom it had been suggested by some very skilful superintendant of metallic operations. "When he," to use the words of Zanichellius, "had carefully melted a great quantity of iron-ore, and when, having finished his preparation, the iron began again to return into a solid state, a portion of it swelled into a large and apparently hollow mass. Having broken this mass with the mallet, a most agreeable appearance was presented. The whole interior crust of this inflated mass was reduced into an innumerable number of pyramids, each pyramid being four-sided, and each of the planes which contained the pyramid having the appearance of being indented and grooved." This description is illustrated by a figure. Additional notices of crystallised iron have been given by Grignonus, Pasumotus, and Romeus Insulanus. In latter times, Guyton de Morveau imagined that he had made new discoveries concerning the crystallisation of iron and steel; but he was unacquainted with the more complete and satisfactory observations of Grignonus and others; and what he has described is nothing more than the first principles of crystallization, previously ascertained by alchymists, and denominated *rete vulcani*.

Crude iron, called *Frischeisen*, which is produced in iron-furnaces, possesses the property of crystallisation. I have ascertained that the form of the crystals is octaedral. Grignonus has described and sketched cubic reguline iron. Pasumotus also procured from the cavities of a furnace belonging to a foundery a specimen of cubical iron, which, according to the description of Grignonus, was found connected with iron amianthus. Cubical crystallisations very frequently occur in substances where the principal form is a regular octaedron.

The crystallisation of malleable iron may frequently be ascertained, by examining the fracture of iron-rods. Iron appearing granular in its fracture, owes its texture to the intersected crystallisation, which is the more perfect, in proportion

to the largeness of the grains, and less so, according as the texture of the iron is assimilated to the texture of steel. Although I cannot agree with the opinion of Epicurus, as handed down to us by Lucretius, and of more recent atomists, that iron owes its hardness and strength to barbed particles, yet I perfectly rely upon those observations and experiments, which prove that the crystalline tendency of the texture is different, according to the various degrees of tenacity possessed by bodies in a given relation. Iron does not possess any great tenacity, except in a particular state of crystalline texture, and this tenacious texture is obtained by a violent compression. We generally find the crystalline texture to be more perfect, in proportion as it is less tenacious; and heated iron, which possesses a very small degree of tenacity, exhibits a very strong tendency to crystallisation. Nor does it appear an improbable supposition, that the elements of various crystalline forms are to be found in the various degrees of flexibility possessed by iron. But this subject does not admit of being more particularly explained in this place.

There are two principal varieties of crude iron, capable of being distinguished, namely, crude iron, vulgarly so called, and steel. If the first variety is produced from a carbonaceous mixture, it contains more or less of graphite. In the latter variety, on the contrary, carbon is more equally distributed through the whole mass; and if it is produced from minerals containing manganese, it generally retains a certain quantity of the manganese. In this variety, the tendency to crystallisation is much stronger than in the former, where the crystalline tendency is less, according to the quantity of graphite which it contains. Yet in crude iron, vulgarly so called, when allowed to cool slowly, there appears to be sometimes produced imperfect octaedral crystals; but it is an imperfect formation, occurring also in other metals, and which Grignonus, in a passage quoted p. 476. tab. 13. fig. 1., has described and sketched. But, as has been justly observed by Romeus Insulanus, this metallurgian was mistaken, when he believed the fundamental figure of the crystal to be a rhomboid. In these imperfect crystallisations found in crude iron, the elements of a regular octaedron are distinctly observed. The small particles are joined together by three planes, cutting each other at right

angles, and cutting also the edges of a regular octaedron; but the crystalline formation does not extend to these edges. The greater quantity of the mass is accumulated in the central part of the octaedral formation; and in each of the eight tetraedrons, which may be considered as composing an octaedron, there is a greater or less cavity, so that the lines forming the edges, in which tetraedrons touch each other from without, are curved inwards. Nor do these curved edges form sharp lines, but they are themselves formed by a number of points going off from the three axes of the crystal, and having a direction to these axes, and to each other at right angles. These points, observed by a microscope, form more minute axes, from which lesser points go off at right angles. Many elementary octaedrons in such points are observed apparently laid over each other, so that the points of the lower octaedrons appear to rest upon the lower part of the upper octaedrons, and the dimensions of these elementary octaedrons are contracted at the top, and being piled up one above another, the whole has a resemblance to the elements of a very sharp octaedron, which has been observed by Romeus Insulanus in the passage quoted above.

The strong tendency to crystallisation which appears in crude iron produced from ores containing manganese, admits of an explanation, partly from this circumstance, that generally it contains no graphite, which, having a stronger tendency to crystallise, impedes the crystalline formation of the iron; but partly also from the combination of the iron with manganese, which, according to many analyses, bears a small proportion in quantity to the iron. For it appears to follow, from many experiments, that the tendency of metals in a mixed state to crystallise, is stronger than the tendency of the simple metals of which the mixture is composed. Nay, it appears to be a general law of Nature, that the crystalline tendency of inorganic bodies is greater in proportion as they are thoroughly amalgamated in their mixed state.

Crude iron of the nature of steel acquires, while in the act of cooling, a foliated texture, which becomes more remarkable, according to the quantity of charcoal which is used for its production. There occur also on its surface crystalline folia, about

the length of an inch, cutting each other at various angles, and thus forming little cells; and, by a more accurate examination of these folia, I have often found the entrance of the plates to have the form of a regular octaedron, although their complete regularity of formation may not always be observed.

The folia of crude iron have a vivid brightness, and, when observed by the naked eye, appear almost smooth, but, by the help of the microscope, we perceive in them pinnated grooves, which, running over the whole surface of the folia, prove the tendency of the particles to crystalline formation. This phenomenon is in like manner observed in other foliated metals artificially produced, and sometimes also in natural substances, such as in native silver.

b. Copper.—The crystalline form of copper is well known. Native copper is observed to be frequently crystallised, as also that which is artificially produced by cementation. For the most part it occurs as a regular octaedron, in various forms. Crystalline copper is also sometimes produced by a dry preparation in metallurgical processes. I am indebted to the kindness of Henserus, a promising student, for a specimen of crude copper (schwarz kupfer) produced in the foundry of Reichelsdorf, which possesses the same elements of octaedral crystallisation, as we found in crude iron described above, except that the small particles are more numerous, and more closely connected together.

We now take occasion to notice a very remarkable cupreous production, found in foundries, and which deserves our most particular attention; namely, capillary copper, (*pili cuprini,*) which occurs in cupreous mixtures, where, the surface being first of all cooled by water, it is found in the cavities. This substance has been observed by Swedenborg. Stone mostly composed of copper, contains, besides other sulphuretted metals, sulphuret of copper, which is very closely connected with sulphuret of iron; we also meet with pure copper, which is not observable when the mass is allowed to cool spontaneously, but, when suddenly cooled, appears in detached pili. This phenomenon can be explained by the fact, that sulphuret of copper consolidates quicker than metallic copper; thus the liquid, by

the contracting power of the sulphuret of copper, is pressed through a number of small pores, and receives a determinate form, corresponding to these pores. In proportion as the diameters of the pores are enlarged, the pili become more thick and short; for they cannot stand erect to any height, being curled downwards by the power of gravitation. This explanation shews, that pili cuprini are not crystalline productions; nor do they admit of a comparison with similar forms, occurring in any native metals, such as in silver, where the formation is to be ascribed to an imperfect crystallisation. In the blunter extremities, however, of these pili cuprini, I have occasionally observed planes of octaedrons.

c. Aurichalcum.—Aurichalcum of the first fusion, denominated *arco* or *mengepressu*, having a whitish appearance when cut, exhibits the elements of crystallisation, and a tendency to the octaedral formation. We observe also, that the elementary octaedrons are laid one above another in the direction of the principal axis. When the dimensions of the octaedrons are nearly equal to the elements, then each element formed of quadrangular prisms, has the appearance of quadrilateral apices, contained in transverse hooked lines, which are sometimes erect, sometimes curved and rolled together. This crystalline formation of aurichalcum has been noticed by Grignonus, who has given a drawing of it, though imperfectly executed: it is also noticed by Lampadius.

d. Arsenicated Nickel.—In the formation of cobaltic glass from particles of minerals not oxidised by heat, a mixture of metals takes place, which is called *Speise*, and which is collected at the bottom of the furnace. Along with the cobalt, there is often conjoined arsenicated nickel, which is less easily decomposed by heat than arsenicated cobalt; and for this reason the substance called Speise is almost wholly composed of arsenicated nickel, besides containing also cobalt and bismuth, and some other metals.

If this residuum is cooled in the common manner, it generally shews a tendency to crystallisation in the pinnated lines of the surface; and there may also occasionally be observed very small crystals in the cavities. But, by a slow process of cooling, large crystals are produced, which not unfrequently admit of being

accurately traced. I am indebted to Bernsteinius, superintendant of the cobalt-work at Carlshaven, for a mass of this residuum, so conjoined with charcoal, as to have the appearance of being conglomerated with it, and mixed also with arsenicated nickel, and arseniceous nickel, a decomposition of the former. In this specimen a slow process of cooling by charcoal leads to the formation of more perfect crystals. I have been able to ascertain with accuracy the following crystallizations:

1. A regular octaedron, deeply truncated on the apices.
2. A regular octaedron, truncated on the apices, and bevelled on the edges of the basis.
3. A regular octaedron, truncated on the apices, and on the edges of the bevelment on the basis.
4. A regular octaedron, in which the apices and the lateral edges are truncated.

As the metallic residuum, arising from a preparation of cobalt-glass, runs into and mixes with native arsenicated nickel, it would be of consequence to compare their several crystallisations. But the crystallisations of native arsenicated nickel are still problematical. A remarkable specimen, in which I had an opportunity of observing the crystalline form, appeared to exhibit cubes with truncated apices. This form coincides with those crystallisations which are found in the artificial arsenicated nickel; it may therefore be referred to a regular octaedron.

2. Graphite.

Graphite is a crystalline composition, containing a small quantity of iron, and a large quantity of carbon. Although the proportion in which these component substances are connected together is undoubtedly ascertained, yet of this proportion chemists differ very much in their opinions. Graphite, both in its native and artificial state, deserves repeated chemical examination, particularly with a view of ascertaining whether or not the artificial graphite agrees in composition with the native.

Graphite is plentifully produced by the fusion of iron, from minerals that do not contain manganese, by the addition of a quantity of charcoal. In crude iron it occurs in small scales; but by increasing the quantity of charcoal, it exhibits larger crystals. In this state it is found imbedded in crude iron, or in the

scoriæ which cover the surface of the iron, in crystals about the size of half an inch. In a perfect specimen of these crystals, there are very thin hexangular plates, which may be cut in the direction of the terminating planes into thinner plates, possessing a mixed lustre, but no transparency. On the edges of the crystals we observe very small planes, inclined towards the terminal planes at oblique angles, from which it may be conjectured, that the hexangular plates are the segments of a fundamental rhomboidal form.

Native foliated graphite, which occurs in its most perfect state in Greenland, at times exhibits specimens of crystallisation similar to those of artificial graphite, though rarely in so complete a form.

(To be continued.)

Art. XXV.—*On a Remarkable Plant of the Order* Fungi, *found growing in a Solution of Succinate of Ammonia,* (with a Figure.) By John Fleming, D. D. F. R. S. E. & M. W. S.

The well-known circumstance, that many kinds of fungi make their appearance in a state of healthy vegetation, whenever there is a soil adapted for their growth, without our aid, or the assistance of any visible means, has excited surprise in the minds of the most superficial observers, and bewildered philosophers in their attempts to account for the phenomena of nature. The droppings of corn-fed horses, placed in layers with common earth, will, in the course of a short time, produce a plentiful crop of the common eatable mushroom. Corrupting vegetable or animal matters speedily exhibit a hoary covering of mucor. These different kinds of plants vegetate, and go through all the stages of their existence, whether the soil in which they germinate be exposed to day, or lodged in darkness. Whence it may be asked, do they derive their origin?

The doctrines of equivocal generation offered an easy solution of this question. The supporters of these were disposed to consider chance as bringing together the particles necessary to constitute the germs of the plant, and the soil as supplying the future requisites of its growth and maturity. The total over-

throw of all the modifications of this theory, leaves the inquirer still in the dark respecting the origin of the fungi which appear in new soils and situations.

The microscope, though an instrument of philosophical investigation fruitful of error, has been singularly useful to the botanist, by enabling him to investigate with success the reproductive organs of plants. He has been able, by the help which it affords, to determine the true forms of many seeds, which are too small to be visible to the naked eye, and to develope the structure of the minute organs in which these are prepared, when the ordinary methods of observation could not be employed. These objects, in spite of many difficulties, have been accomplished in reference to the fungi, the situation of their organs of fructification has been determined, and the existence of their numerous, though minute, seeds demonstrated. So minute, indeed, are these seeds now known to be, that they are capable of gaining admittance into the smallest crevice; and so light, as to be easily carried about in the air. These circumstances sufficiently explain the universality of their occurrence, and lead us to suspect their presence, not merely in the earth, the waters, and the air, but even in the living textures of organised beings. They are ready, when favourable combinations occur, to expand into the forms of maturity. But while the lightness, the smallness, and, we may add, the vivaciousness of the seeds of the fungi, account for their presence in almost every situation, the mind is naturally led to reflect on the infinite number of these germs, at present dormant, within us, and around us, which, in the absence of favourable circumstances, may never be permitted to vegetate. And, considering the contingency of their evolution, botanists may expect the appearance of new species in situations, where their occurrence had not hitherto been detected, and, where it might even have been supposed, that their germination could not have taken place

These remarks have occurred, upon contemplating the peculiar circumstances in which the plant we are now to describe made its appearance,—in the phial of a laboratory, and in the midst of a solution of a neutral salt!

In the spring of the year 1818, I had occasion to prepare a neutral succinate of ammonia, by adding to a saturated solution

of succinic acid, the requisite quantity of carbonate of ammonia, likewise dissolved in water. From the previous condition of the two ingredients, the resulting solution was not fully saturated. The quantity, so prepared, did not exceed four ounces by measure, and was contained in a phial with a ground glass stopper. Upwards of three ounces of this solution were employed, at different periods, during that season, in some analytical experiments in which I was engaged. The phial, containing the remainder of the solution, was placed on a shelf, in a closet, having a window facing the north, but not exposed directly to its light.

The phial and its contents, continued in these circumstances, unnoticed and undisturbed, until the month of June last. At that period, when it was my intention to employ the solution for similar purposes as formerly, I was surprised to observe, on one side of the phial, at the bottom, and beneath the surface of the fluid, the plant, such as is represented at Pl. VII. Fig. 5. From the period at which it was first observed, to the end of September, it was frequently looked at, but no change was perceived to take place in its appearance. About this time, however, the heads began to exhibit a downy roughness on the surface, intimating their approach to maturity. Afraid lest the decay of the plant might speedily take place after these appearances, I removed it from its situation, in order to examine its characters.

The *base* consisted of an apparently gelatinous mass, adhering to the glass, rising up on one side to the height of about half an inch, and spreading over more than half of the bottom. The free surface, towards the centre of the liquor, was convex, and supported numerous stems, terminating in enlarged convex heads.

The texture of the base was not so soft and tender as I had anticipated, for it resisted a considerable force to tear it in pieces, and induced me to denominate it *coriaceous.* When a small portion of it was placed under the microscope, and examined with a magnifying power of sixty diameters, its structure was distinctly displayed, as consisting of innumerable closely interwoven fibres.

The *stems* were round, and a little narrower at the base than towards the top. When magnified, they were found, in like

manner, to consist of closely interwoven fibres, which could easily be traced as taking their rise from the base, or as being merely projections of its substance. Many of the fibres of the stems terminate on their surface, with their extremities pointing to the top, and give to it a divergingly striated appearance.

The *heads* were somewhat larger than the stems on which they were supported. Their upper surface was convex, with an entire thick circular margin. They were much less transparent than either the base or the stems. The fibres of which they consisted were much more numerous and closely interwoven, than those in the other part of the plant, and inclosed a small quantity of granular matter, which I was inclined to regard as the seed.

When this plant was first observed, the stem and heads appeared as in the magnified drawing, Figure 6. *a*, *b*. When taken out of the phial for examination, some of the heads exhibited the fibres as beginning to separate from the general mass, as represented at *c*, while the stem remained entire. The Figure *d* exhibits the fibres separating from both the stem and the head, intimating the approaching disorganisation of the whole.

From the preceding description, little doubt can remain that this plant belongs to the old genus Trichia, and to the more recent subdivision of that genus which has been denominated Sphærocarpus. It exhibits, however, the peculiar character of being an aquatic or *subaqueous* plant, and on that account ought probably to be regarded as the type of a new genus. If it has not been previously described, it may be termed *Sphærocarpus fortuitus*. The trivial name will serve to indicate the contingent circumstances by which a soil was prepared for its germination and growth. In this last character, it is more remarkable than any of the other fungi with which I am acquainted. It will even stand in competition with the Uredo nivalis, that singular plant whose soil seems to be the surface of snow in high latitudes, and whose history Mr Bauer has lately so successfully investigated.

The solution in which the Spherocarpus fortuitus had vegetated, still contained a considerable quantity of succinic acid. The ammoniacal portion, however, had nearly disappeared.

Manse of Flisk, Fifeshire,
February 21. 1821.

ART. XXVI.—*Observations on the Natural History of some species of the Genus Larus, or Gull Tribe.* By A. EDMONSTON, M. D., Fellow of the Royal College of Surgeons of Edinburgh, &c.

PART I.

ALTHOUGH there are no birds more universally met with on the British coast than the different species of gulls, there are none respecting whose natural history more doubt and contradiction prevail. The colour of the bill, of the foot, and the irides, are the external parts in the structure of birds which are supposed to undergo the least change during the different periods of their age, and hence these points have been assumed by many ornithologists as invariable tests of positive distinction among them. A little observation might have shewn, that even these parts are greatly changed in size and colour at different ages among individuals even of the same genus, and where the plumage differs also from what we expect it to be, it is impossible to ascertain, by an adherence to these fallacious texts, the particular species of birds under examination. External characters, as far at least as the form and shape of the bill, and the structure of the feet, are concerned, are eminently useful in establishing generic differences between different orders of birds; but those characters which relate merely to the size and colour of parts, are extremely vague and uncertain, when applied singly to fix discriminating marks between similar species of the same genus; and a misplaced confidence in these has not unfrequently been held as sufficient reason for the addition of a new species, when a variety only existed. The form and position of the nest, the colour of the young at different ages, the differences observeable in the general economy and habits of birds, and their anatomical structure, are the points on which accurate comparisons alone can be founded. But as it requires considerable time to trace them, so it but seldom occurs that the opportunity of observing these progressive changes, is presented throughout in detail to the same person, and hence many of

the histories of birds in the works of systematic writers, are drawn from the communications of different individuals, who perhaps have not possessed the command of that combination of circumstances necessary to accurate narrative; and thus authority itself unconsciously imposes on the judgment, and contributes to the propagation of error.

It is not my intention, neither would it suit the limits of a paper of this kind, to enter into a detailed account *ab ovo* of each individual species of the gull tribe; but I shall endeavour, in successive communications, to point out some essential differences among them, which have been overlooked by ornithologists, and to state some of those peculiarities in their instinct and habits of life, which the care and frequency of observing them have enabled me to acquire.

1. *Larus parasiticus*, (Lin. Syst.) Arctic gull, *Scouti Allen*, *Spooi*, (Zet.). Ornithologists mention only one species of this gull. Pennant and others describe the male as having "the crown of the head black, the back wings dusky, and the whole under side of the body white." The female is said to be entirely brown, but of a much paler colour below than above *. I had, by numerous dissections, discovered males corresponding in their external appearance with the individuals described by Pennant as females, and females exhibiting all the external marks which he had ascribed to males. This contradiction led me, some years ago, to investigate the subject with a good deal of attention, and the following is the result of my observations.

The Arctic gulls are migratory. They come to Zetland in April and May, and leave it in September and October, and breed in different places in the country. The Island of Hascassey is between two and three miles long. The south end of it is occupied by dark coloured Arctic gulls of both sexes, resembling exactly the female described by Pennant, and the north part of it by these gulls of both sexes, resembling the male described by the same author. Each kind occupies separate parts also of a hill on the Island of Unst, and they fight obstinately when either kind approaches too near to the ground possessed by the other.

* British Zoology, vol. ii. p. 534.

The following are the peculiarities on the external appearance of what may be denominated the *black* Arctic gull.

Male.—The crown and sides of the head are black. The back, scapulars, and rump, are of a dusky black colour; wings and coverts nearly of the same tinge. The breast, belly, and vent are of a dun mouse colour. The tail consists of twelve feathers, of which the two middle feathers project three inches beyond the rest, and taper at the point.

Female.—The general appearance of the female is much the same as that of the male, but the breast and belly are rather of a leaden than of a mouse colour; and in some individuals a line of yellowish-white nearly surrounds the neck. The two middle feathers of the tail are not quite so long as those of the male.

The weight and dimensions of both are nearly the same. The length is twenty inches, and the breadth between the extended wing three feet and a half. The weight is between fourteen and fifteen ounces.

This bird may be called the *Larus parasiticus niger*.

The following are the particulars of the *white kind* of Arctic gull.

Male.—The crown of the head, upper part of the body and tail, are of a dusky black colour. The under part of the body, beginning at the breast, and continued to the tail, is pure white. The chin and throat mottled with white and mouse-colour. A white line surrounds the neck at its lower part.

Female.—The female very nearly resembles the male, but while the under part of the body of the latter is altogether white, the vent of the female is dusky, inclining to black. The construction of the tail is the same as in the former species.

The size and weight of both are nearly alike. The length is twenty-one inches, and the breadth three feet seven inches and a half. The weight is sixteen ounces. The white kind, therefore, are larger than the black. They are also less numerous, more shy, and not so bold as the other.

To distinguish this latter species from the former, it may be called *Larus parasiticus albus*, or *albi-venter*. It would greatly facilitate the recollection of the names of animals, as well as be more philosophical in itself, if, instead of deriving the appel-

lation of the species from some obscure property in themselves, or from the name of the discoverer, they were to be taken from some obvious and discriminating external character.

In both the black and white species the irides are hazel-brown, and the legs and feet black. The bill is dusky black, and about an inch and a half long, from the cheek to the point of the upper mandible, which is composed of two pieces. The outer piece is horny and hooked at the point, and is overlapped by that which proceeds from the base. This overlapping piece, when removed, leaves a bluish vascular membrane below it, into which the hooked and anterior piece is inserted. The nostrils are linear, and appear like lateral slits at the place of junction of the two pieces of the bill. The under mandible is straight, and has a projection downwards near to the point.

By attending carefully to these circumstances, and to the general description, the two kinds of Arctic gull may be readily distinguished from each other. The mistake of confounding them together, seems to have arisen from the circumstance, that the first description was taken from a male of the white, and a female of the black species, and succeeding naturalists, instead of examining for themselves, have been satisfied with the distinctions which they received.

But the most important fact in the history of the Arctic gull is, that the young bird, in its progressive stages, until it has attained the perfect plumage, is the Larus crepidatus of Linnæus; the Stercoraire of Brisson, the *Labbe à courte queue* of Cuvier, and the Black-toed Gull of Pennant and other British ornithologists. This I have ascertained to be true, from having traced the young ones from the time they came out of the shell, until they had acquired the size, vigour, and habits of the parent gulls. They differ sensibly from each other, even when only a month old, according as they are descended from the black or the white species; and this fact furnishes another argument in favour of the opinion which considers them as distinct. The black-toed gull, described by Bewick, appears to have been the young of the black species three months old, and the one described by Pennant, bears strong marks of having been the young of the white species, but older; for, as is the case with all the individuals of this genus, a considerable time elapses be-

fore they acquire their perfect plumage, and they are continually changing their appearance, until this has been attained. The young of the black species have more of the ferruginous colour than the white ones, which latter, even when but a few weeks old, have again more of a dirty white on the belly. The legs of both are of a leaden colour, and the feet black, with white spots at the upper part of the inner web of each foot. The centre feathers of the tail, although longer than the others, do not exceed them by more than an inch and a half, while, in the parent bird, they are frequently more than three inches longer. But the form and structure of the bill, feet, and tail, the colour of the irides, the shape and general appearance of the body, and the habits and modes of life, are the same as in the oldest Arctic gull; and, therefore, the Larus crepidatus can no longer be considered as a distinct species of gull, without violating the established principles of zoology.

The Arctic gull constructs its nest in a very simple manner, on mossy heaths, on very exposed situations. It lays at first three eggs of a greyish-brown colour, spotted with brown. If they be taken away, it then lays two, and if plundered a second time it lays only one egg. When threatened with a discovery, it often has recourse to the stratagem which the heath-plover and lapwing employ, of fluttering along the ground at a distance from the nest, in order more effectually to mislead. When, however, a person actually approaches the nest, it becomes very bold and fierce, and strikes severely with its bill and feet. Indeed, the Larus parasiticus is one of the boldest and most familiar of the gull tribe. It fears no bird, or even hesitates to attack any animal, of whatever size, that comes too near to its nest. In those situations, where they breed in considerable numbers, no bird of prey is suffered to approach. If, either by accident or design, any individual of that kind be seen, the whole assembly attack and compel him to retire. Hence, in some places, as in the Island of Hascassey, where this gull is numerous, they become the guardians of the young lambs, which the people consider perfectly safe during summer; and, in return for this protection, the gull enjoys the most perfect immunity from plunder or violence of any kind, being held in no less esteem than the stork is in Holland.

The general appearance of this bird is neat and elegant, and the gait is graceful and dignified. Its note very nearly resembles that of the Larus rissa or kittiwake, but is rather more plaintive. With respect to what has been said regarding the circumstance of this bird pursuing the common gull, and obliging it to disgorge part of its food, it appears more probable than the opinion which supposes that the latter is hunted down by it for its excrement. All the gull tribe possess the faculty of vomiting easily what they have swallowed; but to suppose that they have a voluntary power over digestion, would be to admit a violation of the natural habits of all animals.

ART. XXVII.—*On the Specific Gravity of Barley and Scotch Bigg, with the description of a New Instrument for Measuring it.* In a Letter from the Reverend GEORGE SKENE KEITH, D. D. to Dr BREWSTER.

SIR,

I BEG leave to communicate for your valuable Journal an account of the comparative specific gravities of barley and Scotch bigg, of various weights *per* bushel, and of a new instrument which was made under my directions, for ascertaining the specific gravity of different kinds of corn.

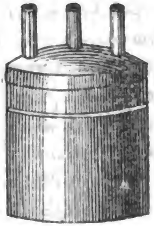
I have been induced to inquire into the relative values of barley and Scotch bigg, in consequence of the acts of 1802 and 1819, which imposed equal duties on malt made from these two kinds of grain, which are so very unequal in point of weight *per* bushel, of marketable price, of extract or saccharine matter by the brewer, and of ardent spirits by the distiller;—in regard to all which subjects I had made experiments, and instituted calculations previous to 1804. But in the Report of the experiments by Drs Hope, Coventry and Thomson, printed by order of the House of Commons in June 1806, I found, in the Table of Raw Grain, among other anomalies, that Suffolk barley, of the second quality, had a specific gravity of 1.307, while its weight *per* bushel was only 49.250 lb.; while Berwickshire barley of the first quality, and weighing 52.062 *per* bushel, had

only the same specific gravity, and Kirkudbright bigg of the second quality had a specific gravity of 1.265; nay, while second Haddington barley that weighed 52.265 *per* bushel, is said to have a specific gravity of 1.333; and third Linlithgow, of 46.375 lb. *per* bushel, to have exactly the same specific gravity. According to the experiments which I have made, the best wheat has only a specific gravity of 1.333; while barley has a specific gravity of different degrees, according to its weight *per* bushel; and Scotch bigg, though in all cases inferior to barley, even when of equal weight *per* bushel, (because it packs or lies closer in a measure, from its being a smaller corn,) has also a specific gravity that nearly corresponds to the relative weights *per* bushel of the different kinds which I submitted to trial.

The following Table exhibits the comparative specific gravities of five kinds of Scotch bigg, and as many of barley, which appear consistent with each other.

1. Scotch Bigg of	41.713 lb. *per* Bushel, Specific Gravity,	1.067	Medium of five kinds,—45.199 *per* bushel, and 1.109 Sp. Gravity.
	44.464 - - -	1.093	
	44.971 - - -	1.113	
	46.457 - - -	1.125	
	48.390 - - -	1.146	
2. Barley of	49.418 *per* bushel,—Specific Gravity,	1.173	Medium of five kinds,—51.172 *per* bushel, and Sp. Gr. of 1.205.
	50.166 - - -	1.181	
	50.652 - - -	1.206	
	52.383 - - -	1.227	
	53.243 - - -	1.242	

The instrument with which these comparative specific gravities were ascertained, consists of two pieces. The first is a brass cylinder of three inches diameter, and a little more than three inches deep, which was made to contain exactly one-hundredth part of a standard Winchester bushel of barley. Three measures of each kind of barley and bigg were weighed; and the medium of the three was multiplied by 100, as the average weight of a bushel. The second piece is a cover made to the first, like the lid of a snuff-box, ground so as exactly to fit the cylinder, but raised in the middle. Three brass



tubes are inserted in this cover, one in the top or middle, and one on each side, but all three level on the top, and communicating with the cylinder, or small bushel. The whole brass, including both cylinder and lid, weighs 7898 grains; and the quantity of distilled water which it contains is 6114 English Troy grains, at 60° of Fahrenheit; both brass and water weighing 14012 grains. The top is then taken off, the greater part of the water is poured out, and 1000 Troy grains of barley or Scotch bigg are mixed with the water left in the cylinder, and stirred for two minutes with a glass-tube, to prevent the adhesion of air-globules to the corn; water being gradually poured in till the cylinder is nearly filled. After this, the top is put on, and more water is poured in, with a hollow glass tube, into one of the brass tubes at the side, till the water rises on the opposite brass tube. If there is not quite enough of water, a few drops are let fall into the middle tube. If there is rather too much, it is taken out from that tube. The whole is then weighed. The additional weight occasioned by the mixing of the barley or bigg being thus ascertained, by subtracting the first weight of brass and distilled water from the second weight of brass, water, and barley or bigg, 1000 grains are subtracted also from the weight of brass and water, to ascertain the weight of water displaced by the barley. Then 1000 grains are divided by the number of grains of water displaced, and the quotient is the specific gravity.

The beam used in weighing these different articles, is a very fine one made by Durward in Aberdeen, for which I paid £ 2, 5s. The weights were brass ones, which were made by William Spring, then in the employment of Messrs Gordon, Barron and Company, and consist of twenty-four pieces, viz. 1000, 2000, 3000 and 4000 grains; 100, 200, 300 and 400 grains; 10, 20, 30 and 40 grains; 1, 2, 3 and 4 grains; $\frac{1}{10}$th, $\frac{2}{10}$th, $\frac{3}{10}$th and $\frac{4}{10}$ths of a grain; and $\frac{1}{100}$th, $\frac{2}{100}$th, $\frac{3}{100}$th and $\frac{4}{100}$ths of a Troy grain *. The whole were made from an average of 32 Troy pounds, the standard Troy weights of the City of Aberdeen, sent down at the Union in 1707, but not exactly aliquot parts

* These twenty-four pieces of metal form 1,111,100 different weights.

of each other; and the Avoirdupois pound was found to contain 7000 of these Troy grains, but is fully a grain weightier than the standard Avoirdupois pound.

It cost this ingenious man much trouble to make a medium Troy pound and grain, from the inequalities of the standard weights; and he was poorly paid with a load of oatmeal which I gave him for his labour.

The brass bushel was also made by William Spring in 1804; but I first got one top or lid, which was flat, and did not answer so well, and then the present lid, which is raised in the crown, by a watchmaker in the burgh of Inverury. I may yet get some improvements made upon it; but the principal method here described is new, and has all the advantages of a hydrostatic balance, while it ascertains the specific gravity of *not one*, but of a multitude of small articles, such as grains of corn.

It is obvious, that a bushel of barley, bigg, or any kind of corn, contains, first the farina, secondly the hull, and, thirdly, the quantity of atmospheric air between the interstices of the corn. Whatever, therefore, has the highest specific gravity of farina, *cæteris paribus*, must yield the greatest quantity of extractive matter, and is the most valuable kind of that species of corn.

I must add, that an equal portion of time, viz. three minutes, was allowed in each of the experiments, to prevent the absorption of water in unequal degrees by the corn which was mixed with it.

When it is considered, that Scotch bigg is so decidedly inferior to barley, in point not only of the climate in which it is raised, and of the relative quality and quantity of extract in the brewery, ardent spirits in the distillery, as well as the price which it brings in the market, when saleable, (which at present it is not), but also that the specific gravity of the individual corns is inferior to barley in a still greater proportion than its weight *per* bushel, I cannot doubt that the Legislature will agree to impose no higher a tax than what is proportioned to its ability to pay to Government. The nation must pay taxes; let them only be proportioned fairly.

If I make any improvements on the instrument which I have invented, I shall take the liberty of communicating them

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to you. And if any gentleman can suggest any alteration or improvement, I shall feel indebted to him. Where truth and science are concerned, there ought to be no jarrings from party-spirit, envy, or interested motives; but candour, whether in confessing errors, or being open to conviction, and a virtuous emulation, which is the best stimulant of a philosopher, should animate all who wish to benefit the public, and obtain a well-earned reputation.

I write this early in the morning, being obliged to attend a Committee of the House of Commons, which will plead my excuse for verbal inaccuracies. I remain, Sir, yours, &c.

GEORGE SKENE KEITH.

EDINBURGH, *May* 16. 1821.

ART. XXX.—*Analysis of a Journal of a Voyage for the Discovery, &c. of a North-West Passage from the Atlantic to the Pacific, in the years* 1819–20.—By Captain W. E. PARRY, R. N., F. R. S. Lond. 1821., 4to., pp. 479., with 20 Plates and Charts; *and of*

A Journal of a Voyage of Discovery to the Arctic Regions. By ALEXANDER FISHER, Surgeon, R. N. 8vo. pp. 320.

THE appearance of Captain Parry's great work, and of the less aspiring narrative of Mr Fisher, has at length quieted the impatience, and gratified, we trust, the highest expectations of the public. The desire of studying the details of this remarkable voyage, and of knowing the occurrences of a year's residence amidst perennial ice, and in a region to which the hardy Esquimaux have scarcely dared to extend their summer excursions, was felt with equal intensity in every part of civilized Europe: And even in countries where the triumph of our naval skill over difficulties hitherto deemed unsurmountable, could not be expected to excite much sympathy,—even there the love of science directed every eye to the new domains which were thus brought within the pale of her research. The circumnavigation of the Globe through an open sea, though accompanied with all

the varieties of naval disasters, had ceased to excite much interest, and, excepting the determination of geographical positions, presented but few points in which philosophy was very deeply concerned. The failure, however, of all attempts to penetrate the frozen barriers of the Arctic Zone; the gloomy desolation which reigned within them; the absence of human and even vegetable life; and the risk of being detained for ever in that frightful climate, gave a peculiar character to every attempt to explore that wilderness of ice and snow. The controversies, too, which succeeded the termination of Captain Ross's voyage, and the absence of the Hecla and Griper during a whole winter, conspired to throw an interest round the last expedition, which we believe was without any former example.

The journals of Captain Parry and Mr Fisher, of which we propose to present a short analysis to our readers, are well calculated to convey a correct idea of the incidents and peculiarities of the voyage. The events of each day are minutely detailed. The singularities of the navigation are perspicuously described. The effects of climate are carefully related. The phenomena of the weather were accurately observed and measured. The action of one of the poles of the terrestrial magnet was particularly attended to; and the Natural History and Mineralogy of the newly discovered islands, were examined with all the care which was consistent with the more urgent objects of the expedition.

The vessels selected for the expedition of 1819, were the *Hecla* and the *Griper*. The Hecla was of 375 tons burthen, and having been built as a bomb-vessel in 1815, was well adapted for stowage, a property of no small consequence, as the expedition had to carry with it two years provisions. She was commanded by Lieutenant W. E. Parry, and had on board a ship's company of *fifty-eight* persons. The *Griper*, which was formerly a twelve-gun brig of 180 tons, was much smaller than the Hecla; and though her accommodations were much inferior, yet she neither sailed so well as the other ship, nor was she able to carry her own supply of provisions; she was commanded by Lieutenant Matthew Liddon, and had a ship's company of 36 persons. Both of these vessels had the whole of their outside, from the keel to some height above the water-line, covered with

an extra lining of oak plank, from three to four inches thick, and a number of beams and additional timbers were put into the holds, in order to resist the pressure of approaching floes of ice. Their bows were also defended from the impulse of floating masses, by strong plates of iron. Standing bed-places were substituted in place of cots *;—and planks, tarpaulins and Russian mats, were provided for housing the ships during winter. The ballast consisted of 70 chaldron of coals in the Hecla, and 34 in the Griper. The men were also furnished by Government with a suit of warm clothes, and a wolfskin blanket. In order to preserve the health of the ships' crews, a large quantity of Messrs Donkins and Gamble's preserved meats and soups was supplied; —antiscorbutics of different kinds were provided, and articles of utility and ornament were carried out to secure the friendship of the Indians or Esquimaux, or to purchase any supplies which the expedition might require.

Equipped with these substantial accommodations, and supplied with scientific instruments of every kind, the expedition set sail from Deptford on the 4th May 1819. It passed the Orkney Islands on the 20th, and on the 15th June it descried Cape Farewell, at the great distance of 40 leagues. On the 3d July it crossed the Arctic Circle, and advanced among the ice on the west coast of Greenland, as high nearly as the 73d degree of latitude, without being able to observe a single opening. Unwilling to proceed to the north of Lancaster Sound, Captain Parry resolved to force his way through this apparently interminable barrier, and after six days of laborious warping through the ice, in which much skill and courage was displayed, he succeeded on the 28th in bringing the vessels into an open sea, and, in three days more, a favourable breeze carried him across Baffin's Bay, and enabled him to land at Possession Bay, (See our chart of Captain Parry's Discoveries, forming Plate V. of vol iv.), for the purpose of making magnetic observations. Mr Fisher, with two men, was directed to proceed up a stream which flows through the valley, and which is about thirty-five or forty yards wide at its mouth, for the purpose of observing

* The hammocks were afterwards resumed, as being much more comfortable than the cots.

the nature and productions of the country; and he here witnessed a fact of a very remarkable kind.

"The first thing," says Mr Fisher, "that attracted our notice in going along the bank of the stream, was to meet human tracks in so perfect a state, that had the place been known to be frequented by man, we should have supposed that people had been here only a few days before; but one of the men who was with me, as well as myself, remembered that we had been on the very same spot where the tracks were observed, last year *, gathering plants, so that we had not the smallest doubt of their being the remains of our own footsteps made last year; for had any Esquimaux been at this place since we were here before, it is more than probable that they would have taken away the pole on the hill, for from what we saw of them last year, nothing could be a greater prize for them than a piece of wood, of the size of that in question. Besides, we observed that the impression of the heel of the shoe was deeper than that of any other part of it, which would not be the case were they the tracks of Esquimaux, for they never have heels to their shoes or boots; and, in fact, the size and shape of the footmarks were such as to satisfy us perfectly as to their origin. From this circumstance we may conclude, that there is no great fall of snow in this country in the winter, for doubtless the melting of it would have effaced these tracks." P. 60.

This singular freshness of human footsteps, if they were those of Mr Fisher and his companions in 1818, indicates a tranquillity among the elements, which could scarcely be expected under the Arctic Zone. To efface the impression of a heavy foot upon soft ground, might be supposed to require some considerable action of wind and rain; but, on the other hand, to preserve for eleven months that distinct tracery of the human foot, in which the difference of level between the heel and the sole is distinctly seen, would require a suspension or diminution of those diurnal operations which is to be found on no part of the earth's surface. May not some of the crew of one or other of the fifty whalers who were in Baffin's Bay in 1819, before the arrival of the Hecla, have been landed at Possession Bay?

On the 2d of August the expedition was directly opposite Lancaster Sound. On the 3d they had fairly entered it, and, under the influence of a favourable breeze, they had, before the 4th, completely crossed the mountainous barrier, which, in a deceitful state of the atmosphere, had appeared to Captain Ross

* Captain Ross landed here in 1818, and erected on the top of one of the hills a pole, which still remained.

to shut up this celebrated Sound. The decision of this long agitated question created, as might have been expected, much interest on board, and did not fail to excite those hopes of future success which a different result would have in a great measure extinguished. The land which they passed on the 4th August, namely, from *Brooking Cuming's* Inlet to *Cape Fellfoot*, differed from any that had been previously seen. It appeared like an immense wall in ruins, rising almost perpendicular from the sea to the height of about 500 feet. The surface of the precipice consisted of horizontal strata, some of which projected farther out than the rest, detaining the debris of the superincumbent rocks, and forming a succession of taluses of different inclinations. The precipices thus assumed a variety of shapes and sizes, and the whole of this bold coast had a very interesting appearance *.

On the 5th of August, when they had nearly reached *Prince Leopold's Isles*, their progress to the west was completely checked by a compact body of ice, which it was impossible to penetrate. They had, therefore, no choice but to wait for the dissolution of this immense barrier, or to follow the open sea to the southward. They adopted this last alternative, and bent their course into the *Prince Regent's Inlet.* Here they encountered vast numbers both of the white and black whales, and also several sea-unicorns or narwhals.

The white or Beluga Whale, the average length of which was from 18 to 20 feet, astonished the sailors with a species of music which received the name of the *Whale Song*.

"Whilst we were pursuing them to-day," says Mr Fisher, "I noticed a circumstance that appeared to me rather extraordinary at the time, and which I have not indeed been able to account for yet to my satisfaction. The thing alluded to is a sort of whistling noise that these fish made when under the surface of the water; it was very audible, and the only sound which I could compare it to is that produced by passing a wet finger round the edge or rim of a glass tumbler. It was most distinctly heard when they were coming towards the surface of the water, that is, about half a minute before they appeared; and immediately when they got their heads above water the noise ceased. The men were so highly amused by it, that they repeatedly urged one another to pull smoothly, in order

* Mr Beechey's spirited sketches of this singular coast, given in Captain Parry's work, will convey a correct idea of it to the reader.

to get near the place where the fish were supposed to be, for the purpose of hearing what they called a Whale Song."—P. 73.

In advancing to the south, along the eastern side of Prince Regent's Inlet, they observed that the rise and fall of the tide was about 12 or 14 feet, and the ebb was observed to set to the southward and westward, which led them to conclude that the flood came in that direction, and not through Lancaster Sound*. Another compact barrier of ice, extending obliquely from the west land to the south-east land, again arrested their progress, and they were reduced to the alternative of either waiting for an opening in it, or shaping their course to the north, in order to avail themselves of any favourable changes that might have taken place in the barrier near Prince Leopold's Isles. The last of these plans was thought the most advisable, and they accordingly turned to the north. On the 9th August, to the south of *Port Bowen*, they saw such numbers of the common black whales, that the Greenland masters on board were of opinion, that the establishment of a factory for killing whales, would be likely to turn out a lucrative speculation, as, besides the oil, a great quantity of ivory might be procured from the immense numbers of narwhals that occur in this inlet. One of these fish, which they caught on the 11th, was about 13 feet 5 inches long, and had a horn 4 feet 2 inches in length, while the greatest circumference of its body was 9 feet. On the 12th, the narwhals were seen swimming about at all hours of the day, in shoals. On the 16th, a current was observed, whose direction was NN. W., and which moved at the rate of a quarter of a mile per hour; and on the 20th, they passed *Cape Fell-foot*, where the horizontal strata resemble two parallel tiers of batteries, placed at regular intervals from the top to the bottom of the cliff, affording a grand and imposing appearance. On the same day they passed *Maxwell Bay*, a very noble one, with several islands, and many openings in its northern shore, and on the 22d, leaving *Beechey Island* to the north, they crossed Wellington Channel, in Long. 93° W. which was "as open and navigable to the utmost extent of their view, as any part of

* Captain Parry is of opinion, that a communication exists between Prince Regent's Inlet and Hudson's Bay, either through the channel called Sir Thomas Rowe's Welcome or through Repulse Bay.—See p. 41.

the Atlantic," and which Captain Parry would have explored, had the ice obstructed his progress to the westward. The rapidity, however, of the run from *Beechey Island* to Cape Hotham, held out better prospects, though they were of short duration. A body of ice was seen to the westward, but, a narrow neck of it appearing to consist of loose pieces, the Hecla was pushed in, and, after a quarter of an hour's "boring," forced her way through it, followed by the Griper. On the 23d they passed to the south of *Griffiths Island*; on the 24th, to the south of *Lowther Island*, and between *Young* and *Davy Islands*, (called *Snow Isles* in our chart); on the 25th they passed *Garret Island*; and on the 26th, 27th, and 28th, *Allison's Inlet*, *Cape Cockburn*, and across *Graham Moore's Bay*. On the 28th they landed on *Byam Martin Island*, in Lat. 75° 9′ and Long. 103° 50′, for the purpose of making magnetical observations, and the results which they obtained were of a very unexpected nature. They found that the variation of the needle was now 168° *easterly*, or 192° westerly, having passed 180°, so that they had actually crossed the line of *no variation*, or rather the line of 180° of variation to the north of the magnetic pole. The last observations which they made were on the 22d, in Long. 91° 55′, and Lat. 74° 20′, so that the magnetic pole must be placed somewhere between 91° 55′, and 103° 50′ of west longitude, and certainly not far from the 102d degree *.

This island was estimated to be about 10 miles long. It consisted of white sandstone, and exhibited a more luxuriant vegetation than any of those which they had lately seen. The following account of the traces of human habitation will be read with some interest.

"We saw no animals of any kind on this island; but we found evident proofs of its having been frequented, not only by different species of the brute creation, but that it had also, at some period or other, been inhabited by man; *for at the distance of about a quarter of a mile from the shore, we found the ruins of six huts close together on the side of a hill.* From the dilapidated state of these ruins, it was impossible to draw any certain conclusions as to what time they had been inhabited, but it must certainly have been a long time ago, for nothing remained of them but the stones that marked their size and site; and from the small number of stones that the ruins were con-

* See the following article for a full account of the magnetical results obtained during the expedition. Captain Parry supposes the pole to be nearly in Long. 100°.

posed of, it is probable that they were only temporary residences. They had been all nearly of the same size, that is, about 12 feet long, and from 8 to 12 feet broad, besides a space of about 3 feet square, formed by 4 flags set upon their edge at the end of each hut *. I understand from those who have been often among the Esquimaux huts in Greenland, that they have always a small apartment of this sort at one end of their hut, in which they keep all their provisions; so that we may infer from this circumstance, that the ruins we have seen to-day belong to a small tribe or party of Esquimaux, that were here probably on a summer excursion." P. 102.

"Although we are left in doubt as to what time this island was visited by man, we have very unequivocal proofs of its being recently inhabited by different animals, for we found numerous tracks of what we supposed to be rein-deer, some of them apparently very lately made, and several of their horns, and small portions of their hair, were found in different places where they had been lying. We had an equally good proof of this place being frequented by musk-oxen (*Bos moschatus*, Lin.) for we found the skeleton of one in a perfect state, except that the bones of two legs were separated from the rest, most probably by some carnivorous animal. The skull and horns were perfectly entire; but from the appearance of the horns, and, indeed, of the bones in general, they must have been exposed to the weather at least one winter. Whether the cloven tracks we saw were chiefly those of musk-oxen or rein-deer, it is impossible to say; but if we were to judge from the number of deer's horns we saw, we should be inclined to consider them as being principally those of the latter animal. It would appear that bears also frequent this land occasionally: we found two or three of their skulls, and their tracks were very numerous along the beach."—*Fisher's Journal.*

On the 30th August, a favourable breeze permitted the expedition to advance to the westward among the ice, round the south end of *Byam Martin's* Island. On the 1st September they came in sight of *Melville Island.* On the 2d a party landed upon it, and on the 4th, at seven o'clock in the evening, they crossed the meridian of 110°, and thus accomplished the first portion of the discovery of the North-West Passage which the British Government had considered worthy of a reward. This joyful event was notified officially to the crew, by Captain Parry, in the following manner.

"After prayers to-day (5th September), all hands were called on deck, when Mr Parry told the ship's company, in an official manner, that we had last night passed the meridian of 110° W. of Greenwich, and by that means became entitled to the reward of L. 5000, promised by Parliament to the first ship that reached that longitude

* Captain Sabine describes these huts as circular or rather elliptical, and consisting of stones from 7 to 10 feet in diameter.

beyond the Arctic Circle. He took also this opportunity of informing them, how highly satisfied he was with their past conduct, and that he had no doubt, by continuing the same zeal and perseverance they have hitherto shewn, but that we shall ultimately accomplish the object of the expedition, and by that means not only become entitled to the whole of the pecuniary reward, but to the much more lasting honour of being the first discoverers of the North-West Passage,—an honour indeed which our most illustrious navigators for centuries back sought for in vain. The enthusiasm excited by this short but pathetic speech was truly astonishing; for the ardour that it inspired might be seen in every countenance. * * * * I think it may be considered a remarkable instance in our voyage, that the first anchor we let go since we left England, was in the 110th degree of West Longitude."—*Fisher's Journal*, p. 115.

The expedition advanced to the westward from the 6th to the 18th September, a little beyond *Cape Providence* *, experiencing very considerable difficulties from the heaviness of the drifting ice, which appeared to be coming from higher latitudes. It was now packed close in with the land; the ships were regularly beset in the bay ice on the morning of the 18th, and as the severity of the season was rapidly increasing, Captain Parry had no other alternative, but either to return to some secure harbour to the eastward, or to remain fixed during the winter, upon an exposed coast, without a bay or a headland to afford him the smallest shelter. He therefore availed himself of a fine breeze, and returned to *Winter Harbour* on the 24th, after experiencing very serious obstructions from the driving floes, one of which forced the Griper aground on the beach.

The mouth of *Winter Harbour* is partly guarded from the violence of the sea by a reef of rocks, over which there is in

* This Cape received its name out of gratitude to Providence for the recovery of a party from the Griper, that was nearly lost on Melville Island. Seven men had set out on the 11th to surprise some rein-deer and musk-oxen. Having lost their way a few hours after leaving the ship, they wandered about without any object to guide them, till, on the 12th, they descried a large flag-staff, which Captain Parry had erected as a beacon to direct them. Four of the party made for the flag-staff, and the other three, mistaking it for a smaller one erected before, walked in the opposite direction. The first party halted all night in a hut of stones and turf, kindled a little fire to warm themselves, with gunpowder and moss, and subsisted on raw grouse. The other party arrived at 10 P. M., on the 13th, after an absence of ninety-one hours, exhausted with cold and fatigue, and frost-bitten in their toes and fingers. The means which were taken by Captain Parry in behalf of these unfortunate individuals, reflect the highest credit upon his sagacity as well as his humanity.

some places scarcely a fathom of water, and between that reef and the land there is a bar, with only $3\frac{1}{2}$ fathoms in some places. The harbour itself being about *three miles* long, it was thought proper that the ships should be stationed about half a mile from the top of it; but the whole being completely frozen over, it was necessary to cut a canal for the ships through the solid ice. The following account of this arduous operation is given by Captain Parry.

" As soon as our people had breakfasted, I proceeded with a small party of men, to sound, and to mark with boarding-pikes upon the ice the most direct channel we could find to the anchorage; having left directions for every other officer and man in both ships to be employed in cutting the canal. This operation was performed by first marking out parallel lines, distant from each other a little more than the breadth of the larger ship. Along each of these lines a cut was then made with an ice-saw, and others again at right angles to them, at intervals of from ten to twenty feet; thus dividing the ice into a number of rectangular pieces, which it was again necessary to subdivide diagonally, in order to give room for their being floated out of the canal. On returning from the upper part of the harbour where I had marked out what appeared to be the best situation for winter quarters, I found that considerable progress had been made in cutting the canal, and in floating the pieces out of it. To facilitate the latter part of the process, the seamen, who are always fond of doing things in their own way, took advantage of a fresh northerly breeze, by setting some boats' sails upon the piece of ice, a contrivance which saved both time and labour. This part of the operation, however, was by far the most troublesome, principally on account of the quantity of young ice which formed in the canal, and especially about the entrance, where, before sun-set, it had become so thick, that a passage could no longer be found for the detached pieces, without considerable trouble in breaking it. At half past seven P. M., we weighed our anchors, and began to warp up the canal, but the northerly wind blew so fresh, and the people were so much fatigued, having been almost constantly at work for nineteen hours, that it was midnight before we reached the termination of our first day's labour. I directed half a pound of fresh meat per man to be issued as an extra allowance, and this was continued daily till the completion of our present undertaking. All hands were again set to work on the morning of the 25th, when it was proposed to sink the pieces of ice as they were cut under the floe, instead of floating them out, the latter mode having now become impracticable, on account of the lower part of the canal through which the ships had passed being hard frozen during the night. To effect this it was necessary for a certain number of men to stand upon one end of the piece of ice which it was intended to sink, while other parties hauling at the same time upon ropes attached to the opposite end, dragged the

block under that part of the floe on which the people stood. The officers of both ships took the lead in this employ, several of them standing up to their knees in water frequently during the day, with the thermometer generally at 12°, and never higher than 16°. At 6 P. M. we began to move the ships. The Griper was made fast astern, and the Hecla and the two ships' companies being divided on each bank of the canal, with ropes from the Hecla's gangways, soon drew the ships along to the end of our second day's work. I should on every account have been glad to make this a day of rest to the officers and men; but the rapidity with which the ice increased in thickness, in proportion as the general temperature of the atmosphere diminished, would have rendered a day's delay of serious importance. I ordered the work, therefore, to be continued at the usual time in the morning; and such was the spirited and cheerful manner in which this order was complied with, as well as the skill which had now been acquired in the art of sawing and sinking the ice, that, although the thermometer was at 6° in the morning, and rose no higher than 9° during the day, we had completed the canal at noon, having effected more in four hours than in either of the two preceding days. The whole length of this canal was 4082 yards, or nearly *two miles and one-third*, and the average thickness of the ice was seven inches. At half past one P. M., we began to track the ships along in the same manner as before, and at a quarter past three we reached our winter quarters, and hailed the event with three loud and hearty cheers from both ships' companies." P. 97.

The whole of the masts were dismantled except the lower ones;—the boats, yards, masts, and rigging, were deposited in a shade erected for them on shore; and a housing raised over deck, as the covering of their winter's habitation. The sun had not entirely deserted the parallel of Winter Harbour. He still shot a few uncertain beams from the southern horizon; but even these were withdrawn on the 4th of November, and our voyagers were left in their dreary exile, with the certainty of losing the light of the sun for nearly three months, and of having only the twilight of an Arctic winter to guide them in their pursuits and amusements. The prospect, too, of being detained in a state of inaction for at least ten months, and the risk of an unusual severity of winter, which the summer heats might be unable to reduce, must have presented even to the best regulated minds some pictures of the future, marked by various depths of outline, but all filled up with much gloomy colouring. It is difficult to classify the varieties of form in which true heroism is generally displayed. History and patriotic feeling have wisely thrown a splendour round that species of animal courage which

willingly exposes, and cheerfully surrenders life for the good of our native land;—but, in the estimate of unbiassed judgment, this instinctive passion sinks to the lowest point of the scale of intellectual heroism. The honours which it receives during life, and the reputation which it secures at its surrender, give it the character of a speculation in which few aspiring minds would be unwilling to embark. But how few are there, who, in the pursuit of some useful object, would expose themselves to the horrors of a polar winter, where Providence has not allowed the germ of human life to spring, where the sun withdraws his presence for three months, and where the contingencies of climate might throw round them an icy barrier, and shut them out for ever from the rest of their species! The officers and crew of the Hecla and the Griper have certainly exhibited this species of true courage; and we should have been disposed to give it the precedence of all others, had we been unacquainted with the endurances of Sir Charles Giesecké, who, animated by the love of science, spent about seven years in Greenland, navigating its dangerous friths, climbing its precipitous cliffs, and inhabiting the huts, and subsisting on the fare, of its wretched inhabitants.

The arrangements made by Captain Parry, to provide amusements and occupations for the winter, were of the most judicious description. He ordered the crew to be mustered in divisions at nine o'clock in the morning, and six o'clock in the evening of every day, in order to see that they were all clean and sober, and to afford an opportunity of examining the state of their bed-places. He established a weekly newspaper, called the North Georgia Gazette and Winter Chronicle*, and every fortnight the crew were amused with plays, acted by the officers, some of which were written for the occasion, with the view of inspiring a zeal and ardour for accomplishing the objects of the expedition. Frequent hunting parties were arranged, for the double purpose of amusement, and of supplying the crew with fresh provisions; and every thing was done to beguile the tedium of

* This Gazette, of which Captain Sabine was the Editor, consisted of twenty-one numbers, the first of which appeared on the 1st November 1819, and the last on the 20th March 1820. It has just been published, chiefly in order to gratify the desire which has been so universally expressed, of seeing the manuscript; and it does great credit to the good humour and intelligence of its authors.

the winter, by keeping both the minds and bodies of the crew in a state of constant occupation and excitement.

The following description, given by Captain Parry, of the dreariness of external nature in the Arctic regions is full of interest.

"The officers were also in the habit of occupying near two hours in the middle of the day in rambling on shore, even in our darkest period, except when a fresh wind and a heavy snow-drift confined them within the housing of the ships. It may be well imagined, that at this period there was but little to be met with in our walks on shore, which could either amuse or interest us. The necessity of not exceeding the limited distance of one or two miles, lest a snow-drift, which often rises very suddenly, should prevent our return, added considerably to the dull and tedious monotony which day after day presented itself. To the southward was the sea, covered with one unbroken surface of ice, uniform in its dazzling whiteness, except that in some parts a few hummocks were seen thrown up somewhat above the general level. Nor did the land offer much greater variety, being almost entirely covered with snow, except here and there a brown patch of bare ground in some exposed situations, where the wind had not allowed the snow to remain. When viewed from the summit of the neighbouring hills, on one of those calm and clear days which not unfrequently occurred during the winter, the scene was such as to induce contemplation, which had perhaps more of melancholy than of any other feeling. Not an object was seen on which the eye could long rest with pleasure, unless when directed to the spot where the ships lay, and where our little colony was planted. The smoke which there issued from the several fires, affording a certain indication of the presence of man, gave a partial cheerfulness to this part of the prospect; and the sound of voices, which, during the cold weather, could be heard at a much greater distance than usual, served now and then to break the silence which reigned around us,—a silence far different from that peaceable composure which characterises the landscape of a cultivated country; it was the deathlike stillness of the most dreary desolation, and the total absence of animated existence. Such indeed was the want of objects to afford relief to the eye or amusement to the mind, that a stone of more than usual size appearing above the snow, in the direction in which we were going, immediately became a mark on which our eyes were unconsciously fixed, and towards which we mechanically advanced.

"Dreary as such a scene must necessarily be, it could not, however, be said to be wholly wanting in interest, especially when associated in the mind with the peculiarity of our situation, the object which had brought us hither, and the hopes which the least sanguine among us sometimes entertained of spending a part of our next winter in the more genial climate of the South Sea Islands. Perhaps, too, though none of us then ventured to confess it, our thoughts would sometimes involuntarily wander homewards, and institute a comparison between the rugged face of nature in this de-

solate region, and the livelier aspect of the happy land which we had left behind us."—*Captain Parry's Journal*, p. 124.

It will, we doubt not, be considered as a very interesting, as well as an important result of this expedition, that the human frame has been found capable of preserving a healthy and cheerful existence, in a climate whose mean temperature is nearly the zero of Fahrenheit's scale, or 32° below the freezing point, and where the mercury occasionally descends so low as 54° beneath zero. Such a severe climate was never supposed to exist even in the imaginations of the poets, and the Pole itself, which was proverbially the point where the hoary desolations of the Arctic regions had concentrated their influence, was considered to have a mean temperature of only + 32° of Fahrenheit. Nay, it is remarkable, (as if the observers had conspired to give point to the antithesis,) that the *mean temperature of the four summer months, at Melville Island, is exactly the same as the mean temperature of the year formerly assigned to the North Pole itself!*

The greatest cold experienced by Captain Parry was quite tolerable in calm weather, and we believe that less inconvenience was experienced from it by the party, than has often been felt in Canada and Siberia. One of the crew of the Griper, who had lost his way in a hunting excursion, returned with one of his hands much frost-bitten. It was at first as hard as a piece of marble, but by successful treatment, it recovered so far, that he lost only a part of each of the four fingers of his left hand. Another sailor, who had his hands frost-bitten, came on board in such a state, that when his hands were immersed in a tub of cold water, for the purpose of being thawed, the cold communicated to the water created a film of ice on its surface. The skin and nails came off some of the fingers, and the rest were amputated. One of the most remarkable effects, however, of severe cold, was its influence on the mental as well as the corporeal faculties. On the 5th of October, two of the gentlemen of the expedition, who had exposed themselves to severe frost in the ardour of pursuing a wounded stag, were sent for by Captain Parry. Upon arriving in his cabin,

"They looked wild, spoke thick and indistinctly, and it was impossible to draw from them a rational answer to any of our questions. After being on board for a short time, the mental faculties appeared gradually to return with the returning circulation; and it

was not till then that a looker-on could easily persuade himself that they had not been drinking too freely. To those who have been much accustomed to cold countries, this will be no new remark, but I cannot help thinking, that many a man may have been punished for intoxication, who was only suffering from the benumbing effects of frost; for I have more than once seen our people in a state so exactly resembling that of the most stupid intoxication, that I should certainly have charged them with that offence, had I not been quite sure that no possible means were afforded them on Melville Island to procure any thing stronger than snow-water."—*Captain Parry's Journal*, p. 108, 109.

The only other affliction which arose from the weather, was what is called in America *snow-blindness*. It began by a sensation like that which is felt when sand or dust gets into the eyes. A solution of sugar of lead removed the complaint in two or three days, and the recurrence of the disease was prevented by the use of a piece of crape.

The scurvy appeared in the months of March and April, but the invalids all recovered, in consequence of Captain Parry's having been at much pains to raise some mustard and cress for them in his own cabin.

The reappearance of the sun on the 3d February, was, after an absence of ninety-two days, joyfully welcomed by the inhabitants of Winter Harbour. The weather gradually improved. The shooting excursions were resumed, and in order to break the monotony of the spring, an expedition was projected across Melville Island, in order to ascertain its breadth, and examine the state of the sea to the north.

This expedition, consisting of Captain Parry, Captain Sabine, Mr Fisher and others, amounting in all to thirteen, set off on the 1st of June.

The following extract will convey a correct account of the nature of the country as seen during their second day's journey.

"Shortly after we started this morning, we came to a small lake, about half a mile in length, and 200 yards in breadth; a considerable part of it was clear of ice, which led us to suppose that two eider ducks, that flew past us a little while before we came to it, had come from it. Soon after we passed this lake, we saw several ptarmigans, and in the course of the night shot seven of them as we went along. Between 2 and 3 o'clock in the morning, we got to the NW. end of a range of hills, which terminate the view to the N. from Winter Harbour. From the top of these hills we could see the ships' masts very plainly with the naked eye, the distance being, as nearly as we could judge, ten or eleven miles. From these hills also we had a very extensive view of an immense plain, extending to

the north and west of us. It was completely covered with snow, and so level, that had we not been convinced that it was considerably higher than Winter Harbour, we should be apt to suppose that it was the sea; but as this objection could not be started against its being a large lake, some were of opinion that it was so; on approaching the border of it, however, we were soon satisfied that it was only a level plain. Our route, from the time of our leaving the ships, until we came in sight of this plain, was over ground, generally speaking, pretty even, but gradually ascending. Its surface, for most part of the way, was at least more than two-thirds covered with snow. Soon after we got to the confines of the plain above mentioned, we saw a rein-deer and a fawn coming across it from the southward. The fawn appeared to be very young, and rather of a darker colour than the doe. The latter did not differ in this respect from those that we killed in the beginning of last winter." —*Fisher's Journal*, p. 199.

The party arrived at the sea at *Point Nias*, in Latitude 75° 34′ on the 7th of June. From this they passed over to *Bushnans Cove* on *Liddon's Gulf*, which they reached on the 11th. On the 12th they went to *Hooper's Island*, and returned in safety to *Winter Harbour* on the 15th, after a journey of 180 miles. The most remarkable event in this tour was the discovery of the remains of six Esquimaux huts, about 300 yards from the beach of Liddon's Gulf. These huts, situated in Latitude 75° 2′ 37″, and west Longitude 111° 37′ 17″, were exactly the same as those formerly described.

The state of the ice on the 1st of August permitted the expedition to leave Winter Harbour, and every thing seemed to predict a successful voyage to the west. These expectations, however, were soon disappointed. The situation of the ships among the masses of driving ice was often precarious, and when they reached *Cape Dundas*, at the west end of Melville Island, on the 16th, the ice from the north compelled them to abandon all hopes of prosecuting their voyage to the west, after obtaining a glimpse of three capes to the south, which they called *Banks'* Land.

Captain Parry, resolved, therefore, to advance, if possible, to the south, but after waiting in vain for an opening in the ice, he renounced this plan also, and on the 30th August he publicly notified his intention of returning to England. No events of any great interest marked the return of the expedition, excepting a communication with the Esquimaux, who inhabit an inlet called the River Clyde, on the western shores of Baffin's Bay.

"As we were standing in this evening towards the place where Mr Lee told us the Esquimaux lived, four canoes were observed paddling towards us. While they were yet at a considerable distance off, we could hear them making a great noise, which they continued to do as they approached us. They came alongside without the least hesitation, and one of our boats being there, our people assisted them in getting out of their canoes, which were all hoisted on board, and helped them up the side. On getting on board they evinced no signs either of fear or astonishment. On finding themselves in security, their first act was to turn to dance: if turning round, jumping, and other wild gesticulations, deserve that appellation. At the same time that they were shewing us their accomplishments in the dancing way, they gave us a specimen of their vocal talents also; but to call the two or three monotonous ejaculations that they uttered a song, would certainly be a misapplication of the word, for the whole of their melody consisted only of these three words, "*hey, yey, yagh,*" which they repeated with great rapidity, and with vehemence in proportion to the movements of the body: these were at first very violent, but by degrees became more moderate, from being unable, I imagine, to continue such fatiguing exertions." Fisher's *Journal,* p. 272.

After going below, "they skipped about, and hey yay gagh'd more furiously than ever," apparently, as Mr Fisher conjectures, from a desire to please the sailors. The oldest man, who was about sixty years of age, and only 4 feet 11 inches high, sat down very composedly to have his picture taken. He seemed a great adept at mimickry, and imitated with an air of the most complete buffoonery and good humour the attitudes of Captain Parry who shewed him the proper posture; the other two were young men, about 5 feet 5 inches high, and between twenty and thirty years of age. Their dress differed little from that of the Esquimaux of Greenland, but their canoes were not so neat. The frame work was made of firwood, and the paddles, which were 9½ feet long, were of the same material, and the rim of the blades was neatly edged with bone. They had some small pieces of iron, but bone in general supplied its place *. An exchange of articles soon commenced. They received for their seal-skins and a canoe, articles of utility, such as knives, scissars, needles, nails, gimblets, and the sailors gave them several useful and ornamental donations. As soon as they received any article, they touched it with their tongue, "appa-

* Captain Parry mentions it as a singular circumstance, "that when a Kaleidoscope or a Telescope was given them to look into, they immediately shut one eye."

rently to shew that it was then legally their property." A boat was sent on shore with the man who sold his canoe to Captain Parry, and the officer who accompanied it purchased another for his dirk, a Flushing-jacket, a shawl, a knife, and some beads.

On the 7th September, the day following, the ships stood into the fiord where the Esquimaux landed, in order to visit their habitations, which consisted of two tents, supported by a long vertical pole of whalebone 14 feet high, and rising 4 or 5 feet above the seal-skins which formed their roofs and sides. They were about 17 feet long, and from 7 to 9 feet broad.

" The inhabitants of these huts," says Mr Fisher, " they found to be the four men who visited us last night, four women, and nine children. One of the women was very old, and was supposed to be the wife of the old man. Two of the others were judged to be about thirty years of age, and they were supposed to be the mothers of all the young family. One of them was pregnant. The fourth damsel appeared to be too young to be yet living a conjugal life; and there was another circumstance remarked with regard to her, that was considered as a mark that she had not yet arrived at the happiness of a matrimonial life. The circumstance alluded to is, that the other three were tattoed, whilst she was not; from which it was supposed, that this barbarous decoration was the distinguishing badge of a married woman. This piece of artificial beauty consisted of two curved lines, extending from the outer corner of the eyes down to the upper lip. The convex side of these lines pointed backwards, and their junction at their lower end formed an acute angle. The chin and lower lip were also tattoed by straight lines which diverged from the mouth downwards. Whether it was owing to her being free from these barbarous scores or not I do not pretend to say, but they who saw her speak of the young girl comparatively as a great beauty: whilst they describe the old dame as the picture of ugliness. With respect to their dress, the women seem to have been habited nearly in the same manner as the men, viz. in leathern jackets, boots, and breeches."

The huts of these people were of the same shape and size as those of Melville Island, and were less filthy than those of the Esquimaux usually are. They have stores of sea-horses' flesh covered with stones, along the beach, and they had no fewer than fifty or sixty dogs. These dogs devour their food in a most ravenous manner, and when a bird is given them they swallow it, feathers and all: one of them which Captain Parry purchased, though regularly fed, eat up one day a piece of canvas, a cotton handkerchief, and part of a check shirt. The Esquimaux had also a piece of a file set on a bone handle, like

an adze in miniature, and they exhibited several beads different from those they had acquired on board. The fiord where they lived is full of small islands. It has 180 fathoms of water within the entrance of it, and not above a mile from the shore, and it appeared to be about four or five miles broad. Their winter huts were seen about two miles farther up the bay than their tents. They were partly excavated from a bank facing the sea, and the rest built round with stones.

In studying the character of this rude people, it is impossible to read, without the highest satisfaction, the following account which Captain Parry has given of their circumstances and manners.

" Upon the whole, these people may be considered in possession of every necessary of life, as well as of most of the comforts and conveniencies which can be enjoyed in so rude a state of society. In the situation and circumstances in which the Esquimaux of North Greenland are placed, there is much to excite compassion for the low state to which human nature appears to be there reduced, a state in few respects superior to that of the bear or the seal which they kill for their subsistence. But with these it was impossible not to experience a feeling of a more pleasing kind; there was a respectful decency in their general behaviour, which at once struck us as very different from that of the other untutored Esquimaux, and in their persons there was less of intolerable filth, by which these people are so generally distinguished. But the superiority for which they are the most remarkable, is the perfect honesty which characterised all their dealings with us. During the two hours that the men were on board, and for four or five hours that we were subsequently among them on shore, on both which occasions the temptations to steal from us was perhaps stronger than we can well imagine, and the opportunity for doing so by no means wanting, not a single instance occurred to my knowledge of their pilfering the most trifling article. It is pleasing to record a fact no less pleasing in itself than honourable to these simple people."—Captain Parry's *Journal*, p. 287.

On the 8th of September, the expedition proceeded southward, the Hecla arrived in Leith Roads on the 3d November, after an absence of eighteen months, and Captain Parry had the high satisfaction of seeing every officer and man on board both ships (with only *one* exception, out of *ninety-four* persons,) return to their native country in as robust health as when they left it.

In reading the details of this celebrated expedition, it is impossible not to admire the high qualifications which Captain Parry exhibited as a navigator and Commander. The con-

summmate skill with which he conducted his ships through the intricacies of an icy sea; the acuteness and discernment with which he decided on the perplexing alternatives which were often presented to his judgment; the prudence and moderation and temper with which he managed his little colony in Winter Harbour; the kindness and humanity which he unceasingly displayed in providing for the health and comfort of the crew; and the success which finally crowned his exertions, entitle him to a preeminent rank among the most illustrious European navigators. In accomplishing the objects of the expedition, he was ably seconded by Lieutenant Liddon, and all the officers of both vessels, and from the zeal, the ability, and the scientific knowledge of Captain Sabine, he has been enabled to enrich his work by many valuable contributions to the physical and natural sciences. But while we offer our humble approbation to those intrepid individuals, who have so admirably executed the objects of the expedition, we should not forget how much of its success was due to the discrimination and the liberality of the Admiralty; and especially to the acuteness and sagacity of one eminent individual, whose knowledge of Arctic Geography enabled him to anticipate the existence of unknown lands, and to pursue the object of his researches in spite of all the obstructions which ridicule, and sophistry, threw in his way *.

Art. XXIX.—*Account of the Magnetical, Meteorological and Hydrographical Observations made during the Expedition to Lancaster Sound.*

In order that the Narrative of the Expedition which we have given in the preceding pages, might not be encumbered or interrupted by scientific details, we have reserved for a separate article an account of the magnetical, meteorological and hydrographical observations which were made on board the Hecla and Griper.

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* We would strongly recommend to Mr Barrow the consideration of the probability of reaching the North Pole by means of an expedition which should spend one or two winters in Spitzbergen, in order to take advantage of any favourable openings in the ice. The scientific results of a year's residence in that island, would, independently of any ulterior object, amply repay the expence which might attend it.

1. *Magnetical Observations.*

As the measures of the variation and dip of the needle could be taken only on icebergs and islands, out of the reach of the ship's attraction, they are not so numerous as might have been expected; but they make up in importance for what they want in quantity, and will be studied with much interest by the philosophers of all countries. The following Table contains the whole of the results given in Captain Parry's work, and deduced from observations made principally by Captain Sabine *.

Observations on the Variation of the Needle.

	North Latitude.	West Longitude.	Variation West.	
1819, June 19.	59° 49′	48° 9′	48° 38′ 21″	On ice.
—— 26.	63 58	61 50	61 11 31	On ice, 220 yards distant
—— 27.	63 44	61 59	60 20 12	On ice. [from ship.
—— 30.	63 26	62 9	61 50 12	On ice, 200 yards distant.
—— 30.	63 29	62 8	60 55 48	
July 15.	70 29	59 12	74 39 0	On an iceberg.
—— 17.	72 0	59 56	80 55 27	On ice, 200 yards distant.
—— 23.	73 5	60 11½	82 2 40	On ice, 250 yards distant.
—— 23.	73 3	60 12½	82 37 30	
—— 24.	73 0	60 9	81 34 0	
—— 31.	73 31	77 22½	108 46 35	Possession Bay.
Aug. 3.	74 25	80 8	106 58 5	Iceberg.
—— 7.	72 45	89 41	118 16 27	E. coast of Regent's Inlet.
—— 13.	73 11	89 22½	114 16 43	On ice.
—— 15.	73 33	88 18	115 37 12	E. coast of Regent's Inlet.
—— 22.	74 40	91 47	128 58 7	Beach at Cape Riley.
			East.	
—— 28.	75 9	103 44½	165 50 9	SE. point of B. Martin's
Sept. 1.	75 3	105 54½	158 4 13	On ice. [Island.
—— 2.	74 58	107 3	151 30 3	On Melville Island, and during an excursion into the interior of it.
—— 6.	74 47	110 34	126 17 18	
—— 15.	74 28	111 42	117 52 22	
Winter Harbour	74° 47′ 13″	110 49 0	127 47 50	
1820, June 3.	75 6 52	110 27 40	128 30 14	
—— 7.	75 34 47	110 35 52	135 3 55	
—— 11.	75 12 50	111 51 54	125 15 22	
—— 12.	75 5 18	111 56 58	123 47 58	
—— 13.	75 2 37	111 37 10	126 1 48	
—— 15.	74 48 33	111 11 49	123 5 30	
Aug. 5.	74 24	112 53	110 56 11	
—— 10.	74 26	113 48	106 6 38	
—— 18.	74 25	112 41	111 19 15	
—— 25.	74 27	112 11	114 34 45	
Sept. 3.	71 16	71 18	91 28 32	W. coast of Davis' Strait.
—— 7.	70 22	68 37	80 59 17	Inlet called River Clyde.

* The instruments with which these observations were made, are described in the *Phil. Trans.* 1819.

Observations on the Dip of the Needle.

	North Latitude.	West Longitude.	Dip.	
1819, March	51° 31′ ″	0° 8′	70° 33′ 27″	Regent's Park, London.
June 26.	64 0	61 50	83 4 41	Ice, Davis' Strait.
July 17.	72 0	60 0	84 14 9	Ice, Baffin's Bay.
—— 31.	73 31	77 22	86 3 7	Possession Bay.
Aug. 7.	72 45 15	89 41	88 26 71	E. coast of Regent's Inlet.
—— 11.	72 57	89 30	88 25 17	On ice.
—— 15.	73 33	88 18	87 35 95	N. Side of Barrow's Strait.
—— 28.	75 10	103 44	88 25 58	B. Martin's Island.
—— 30.	74 55	104 12	88 29 12	Ice, 400 yds. dist. from ship.
Sept. 6.	74 47	110 34	88 29 91	Beach, Melville Island.
—— 11.	74 27	111 42	88 36 95	Melville Island.
1820, July 18.	74 47	110 48	88 43 5	Observatory, Winter Harbour.
Sept. 17.	68 30	64 21	84 21 42	Ice, Davis' Strait.
—— 28.	51 43	0 14	70 33 5	Near London.

The change in the direction of the variation from *Westerly* to *Easterly*, must have taken place about the 102d degree of west longitude, and shews that the expedition must at that point, which they passed on the 27th of August, have been a few degrees to the north of the Great Magnetic Pole. This conclusion agrees very wonderfully with the position of this pole, as assigned by M. Hansteen, who places it in 1819 in 69° 40′ of North Lat., (5° 23′ to the south of the ships on the 27th August), and in 90° of West Longitude.

After entering Lancaster's Sound, the deviation produced by the ship's action increased uniformly and rapidly as the expedition proceeded westward. It increased, also, as they advanced southward into *Prince Regent's Inlet*, and the usual observations for determining the variation on board ship were necessarily abandoned. On the 7th August, in Lat. 73°, they witnessed, for the first time, the curious phenomenon of the directive power of the needle becoming so weak as to be completely overcome by the action of the ship, so that the needle actually pointed to the north pole of the ship. This, however, was observed only with the light and nicely suspended needles; for in the heavier cards, the friction could not be overcome by the ship's action, and they accordingly remained indifferently in any position. On the 8th August, when nearly in Lat. 72°, the directive power of the magnet seemed to be weaker here than ever.

Captain Parry justly conjectures, that the dip would have been greater here than they had observed it, but there was not time to measure it.

From the experiments made at Winter Harbour to determine the variation in the magnetic force, it appears that the time of vibration of Mr Brown's dipping-needle decreased between London and Winter Harbour in the ratio of 481 to 446; and consequently, the force in the direction of the dipping-needle appeared to have increased in the ratio of 1.168 to 1.

From the increase in the times of vibration of three horizontal needles between Sheerness and Winter Harbour, the force acting upon them appeared to have diminished in the ratio of 12.93 to 1; 13.23 to 1; and 13.83 to 1; the mean of which is 13.33 to 1.

2. *Meteorological Observations.*

While the magnetical observations of Captain Parry may be expected to fix, beyond dispute, the position of the western magnetic pole, the meteorological results which he obtained have also settled many contested points respecting the distribution of heat, and have confirmed, in a very remarkable manner, the doctrine of two poles of *maximum* cold, which Dr Brewster had maintained to exist at a distance from the pole of the globe.

The following Table contains an abridged view of the thermometrical results for a whole year, from September 1. 1819 to September 1. 1820, during which period the Hecla was within Lancaster Sound *. From September 1. 1819 to August 27. 1820, within *three days* of a *whole year*, the expedition was on the *south coast of Melville Island*, so that the register may be considered as actually kept for the whole year at Winter Harbour, and as giving, with great accuracy, the mean temperature of that latitude.

* It deserves to be remarked, that the mean temperature of the month of July 1819 in Baffin's Bay, was much colder than the same month in 1820 at Winter Harbour; being 33°.54 in the former case, and 42°.41 in the latter.

TABLE of the Mean Temperature of Twelve Months at Melville Island in 1819, 1820.

	1819.				1820.							
	Sept.	October.	Nov.	Dec.	January.	Feb.	March.	April.	May.	June.	July.	August.
	+			—	—	—	—	—	+	+	+	+
1	33°.00	+ 6°.83	— 1°.00	30°.29	18°.33	20°.87	31°.33	6°.33	8°.58	36°.29	40°.58	36°.21
2	32.79	+ 12.83	+ 3.25	32.96	24.58	31.75	25.00	8.37	6.25	34.17	40.50	34.17
3	34.17	+ 8.75	+ 3.92	16.04	34.62	39.58	31.33	18.71	9.25	35.50	43.83	35.92
4	31.83	+ 9.83	+ 5.50	31.71	40.17	39.96	27.92	14.75	7.67	35.63	39.83	35.62
5	30.58	+ 3.00	— 0.67	31.25	32.00	29.12	16.50	16.62	11.58	34.87	44.33	34.08
6	27.96	— 1.80	— 14.08	27.00	28.58	20.71	2.50	18.75	3.83	32.17	47.67	33.96
7	28.42	+ 6.10	— 11.12	22.29	37.67	24.62	6.17	21.00	0.79	29.63	47.42	34.92
8	30.00	+ 3.75	— 10.04	19.67	35.83	28.92	18.35	20.46	3.00	32.08	48.75	36.46
9	30.67	— 1.83	— 12.75	18.83	34.42	25.83	8.58	21.85	4.67	33.02	43.58	34.79
10	31.00	+ 1.83	— 9.67	19.33	36.17	31.62	4.96	22.96	5.62	32.25	45.67	31.96
11	27.75	+ 4.54	— 18.62	11.21	44.42	39.77	2.25	19.67	4.17	33.92	43.33	31.29
12	29.50	— 4.17	— 28.58	14.42	44.71	42.00	24.00	20.00	8.62	32.54	43.75	34.29
13	26.08	+ 7.60	— 28.50	10.96	45.29	41.58	22.71	22.92	7.62	33.46	46.00	36.92
14	13.79	— 2.50	— 26.08	8.29	35.08	46.33	17.83	19.37	7.50	34.75	48.25	33.22
15	18.92	+ 6.17	— 30.88	11.63	35.73	40.92	16.25	7.33	9.42	34.67	43.00	32.33
16	21.25	— 5.20	— 39.79	13.50	37.08	32.33	21.79	12.33	12.67	33.75	42.87	32.42
17	19.75	— 12.88	— 35.63	4.37	24.50	33.42	17.58	13.62	18.50	34.58	51.08	31.83
18	23.67	— 6.08	— 36.00	5.00	10.25	26.25	8.88	8.17	18.00	37.33	43.12	33.08
19	29.83	— 11.25	— 42.92	17.46	17.50	21.04	13.75	4.00	17.75	37.67	43.17	33.96
20	17.25	— 15.12	— 43.71	22.83	24.46	24.08	11.88	2.21	16.96	36.25	40.50	31.67
21	15.83	— 10.58	— 27.79	23.50	19.00	30.25	15.63	3.17	18.83	38.17	40.33	30.92
22	19.67	— 6.92	— 23.00	31.00	26.00	36.58	13.75	4.63	23.00	44.33	45.04	31.79
23	22.08	+ 0.12	— 25.00	33.83	22.50	37.67	22.42	+ 4.00	27.29	42.08	39.17	31.58
24	20.25	— 2.83	— 15.00	31.17	24.83	40.92	21.50	+ 10.42	32.71	37.00	41.83	31.79
25	13.58	+ 3.71	— 11.75	26.04	26.42	34.54	26.71	+ 4.88	36.33	37.42	43.58	32.29
26	5.00	— 1.08	— 24.79	16.21	31.17	26.33	25.50	— 1.17	33.04	40.50	36.92	28.92
27	15.00	— 10.25	— 18.38	24.58	33.96	27.75	26.17	+ 0.08	39.17	39.33	34.67	27.83
28	17.33	— 19.75	— 28.29	36.75	37.23	29.08	24.17	+ 4.83	34.36	37.17	37.29	28.12
29	11.25	— 24.25	— 31.92	37.38	26.12	29.07	23.88	+ 12.75	26.54	41.92	34.58	29.00
30	5.92	— 26.15	— 33.58	38.96	19.58		20.29	+ 20.38	31.08	43.75	37.25	30.00
31		— 12.17		7.17	24.54		11.50		30.92		36.96	31.75
MEAN,	+ 22.54	— 3.46	— 20.60	— 21.79	— 30.09	— 32.19	— 18.10	— 8.37	+ 16.66	+ 36.24	+ 42.41	+ 32.68

A general abstract of these meteorological observations has already been given in our 4th volume, p. 442.

The greatest heat at Melville Island, was	+ 60° Fahr.	on the 17th July.
The greatest cold at ditto, - was	— 50	on the 15th Feb.
Mean temp. of warmest month, *July*,	+ 42.41	
—— —— of coldest month, *February*,	— 32.19	
—— —— of Winter, *Dec. Jan. Feb.*	— 28.02	
—— —— of Spring, *Mar. April, May*,	— 3.27	
—— —— of Summer, *June, July, Aug.*	+ 37.11	
—— —— of Autumn, *Sept. Oct. Nov.*	— 0.51	
The Mean Temperature for 12 months,	+ 1.33	

If we substitute the mean temperature of August 1819, in place of August 1820, it will scarcely affect the mean results.

	Inches.	
The greatest height of the barometer was	30.86	on the 26th April.
The lowest state of ditto, - - -	29.00	on the 6th March.

These results indicate a very extraordinary degree of cold at Melville Island. According to the Table given by Mr Leslie, after Mayer and Kirwan, the temperature of Melville Island should have been nearly 36°, whereas it is only $1\frac{1}{3}$°, a result which throws into the shade all those speculations respecting the climate of the Arctic Regions with which the public have been so long misled. Nor can this difference between hypothesis and observation be ascribed to any accidental or local cause. The same singular distribution of heat on both sides of Baffin's Bay, is deducible from numerous observations made on the coast of Greenland by Sir Charles Giesecké and the Danish Governors, extending over a period of nearly seven years. The following are the results which we have deduced from these Tables, (which have been kindly communicated to us by Sir Charles Giesecké), contrasted with those of the hypothetical table already mentioned:

	Lat.	Mean Temp. Observed.	Mean Temp. according to Leslie's Table.	Errors of the Table.
Upernavick *, -	72°.32	16°.34 Fahr.	36°.76	20°.42
Omenak, -	71.0	16.60	37.5	20.9
Godhavn, -	69.17	22.04	38.6	16.56
Godthaab, -	64.10	26.07	41.9	15.83
Julianæshaab,	60.43	30.33	44.5	14.17

Captain Parry made various observations on the difference of

* On the 4th of March 1811, the thermometer at *Upernavick* descended to 44° Fahr. *below zero*.

temperature between the sunshine and the shade. The following are those which he has published:

		Shade	Sun	Diff.
1820, Mar. 19. *Mean Temp.* — 13°.75.	9h A. M.	— 24°	+ 24°	48°
	10	— 23	+ 27	50
	11	— 22	+ 28½	50½
	12 Noon,	— 21	+ 29	50
	3 P. M.	— 13	+ 19	32
Mar. 25. *Mean Temp.* — 26°.71.	1 P. M.	— 22	+ 17	37
	2	— 22	+ 25	47
	3	— 22	+ 21	43
April 26. *Mean Temp.* — 1°.17	1h 30′ P. M.	+ 17	+ 6.5	10.5
	2	+ 22	+ 7	15
	2 18	+ 24.5	+ 7.6	16.9
	2 50	+ 21	+ 6.7	14.3
	6	+ 9.5	+ 4.5	5.0
April 27. *Mean Temp.* + 0°.08.	11h 20′ A. M.	+ 15	+ 5	10
	11 30	+ 20	+ 7	13
	11 40	+ 34	+ 9	25
	11 55	+ 24	+ 8.5	15.5
	0 25 P. M.	+ 21	+ 7	14
	1	+ 20	+ 7.5	
	2 20	+ 25	+ 7.7	
	2 45	+ 10	+ 4.5	

The principal meteorological phenomena seen during the progress of the expedition, were *Auroræ Boreales, Paraselenæ and Halos.*

1. *Auroræ Boreales and Columns of Light.*—The Aurora Borealis seems to have been observed much less frequently than might have been expected. On the afternoon of the 25th October 1819, Mr Fisher observed at Winter Harbour two vertical columns of prismatic colours, about 15° on each side of the sun, (which was below the horizon.) They were about 5° long, and their lower end touched the horizon. They preserved the same intensity of colour for about an hour, (from noon to about one o'clock), and then began to vanish, which they did entirely in less than an hour. On the 29th October, Mr Fisher again remarks, that columns of prismatic colours, similar to those above described, were observed *two* or *three* times since the 25th, at the same distance from the sun, and at the same altitude. The aurora borealis, he adds, was seen also two nights ago to the *southward*, but it was very faint.

On the 17th November 1819, at 3 P. M. a very remarkable cloud of a light-brown colour was observed, the centre of it bearing SW. by S. It diverged from a centre at the horizon in straight lines or columns, which extended to a great distance over the surface of the sky. The lower edge

of it, which was straight and well defined,' formed an angle of about 45° with the horizon. "Directly over its centre," says Mr Fisher, "instead of straight lines, it had more the appearance of an immense volume of smoke than any thing else. The whole was compared by our gunner to a powder magazine in a state of explosion. It is probable that this cloud had some connexion with the aurora borealis; for after it had vanished, which took place about six o'clock, that phenomenon was seen in the same part of the heavens that the cloud occupied. It made its appearance, indeed, before the cloud disappeared entirely, but not before it had lost its radiated form, and dispersed so much that nothing particular could be seen about it." Mr Beechy informed Captain Parry that it shone brilliantly for half an hour, disappearing about four o'clock, and that the sun was on nearly the same bearing, and about 5° below the horizon.

On the 15th January 1820, the Aurora Borealis was seen in the form of a "beautiful arch, coincident with the plane of the meridian, and extending from the southern to the northern horizon, a little to the east of the zenith. After remaining stationary," says Mr Fisher, "and of this shape for about ten minutes, it then formed an ellipsis of great extent, whose transverse diameter was also parallel with the plane of the meridian, and situated on the east side of it, and in such a position that the west side of the ellipsis reached the zenith. It remained of this form only a few minutes, and then assumed a variety of shapes, which were constantly varying, being chiefly shooting in streams from the southern horizon to the zenith." "At one time," says Captain Sabine, "a part of the arch near the zenith was bent into convolutions, resembling those of a snake in motion, and undulating rapidly." No sound whatever was heard. After three months absence, the sun re-appeared above the southern horizon on the 3d of February; and during his appearance, a vertical column of beautiful pale red light extended from the upper part of the sun's zenith; the colour of it was most brilliant near the sun, and diminished gradually as it went upwards. It was observed also, that it was not always of the same brilliancy, but that it twinkled, so that the upper part of it vanished altogether for a moment; it then instantaneously brightened up as splendid as before; this twinkling went on in

quick succession during the whole time the column appeared. Its breadth was about equal to the sun's diameter, and its height or altitude, when in its greatest splendour, was between 4 and 5 degrees." It was visible for about 3-4ths of an hour before and after noon. Captain Sabine saw a similar column about ten o'clock, immediately over the spot where the sun was.

Mr Fisher observed other two examples of the aurora borealis in Baffin's Bay, on the 13th September, in Latitude 68°, and on the 3d October in Latitude 60°. The first extended from the west to the south-east point of the horizon; and the second extended in an arch, from east to west, across the zenith. It displayed most of the prismatic colours, as red, orange, yellow and green, and lake was predominant in some parts. It appeared sometimes in immense sheets of light, and at other times it darted in straight columns to the zenith. A sort of serpentine motion was distinctly observed at one time, from west to east, across the zenith. The electrometer was not affected.

The observers of the aurora borealis have frequently maintained, that the stars seen though it appear with their usual brilliancy. Mr Fisher, in particular, makes this remark; but Captain Parry and Captain Sabine thought that they observed a distinct diminution of lustre. There can be no doubt that the brilliancy of the stars is not deeply affected by the beams of the northern lights; but it is equally certain that these lights *must* impair their brilliancy to a certain extent, merely from the action of light upon the retina; and this effect would be the same, even if the stars were placed between the aurora borealis and the observer.

2. *Paraselenæ and Halos.*—On the 1st December 1819, between 7 and 8 o'clock P. M., four paraselenæ, or mock moons, were observed, each at the distance of 21½° from the moon. One of them was close to the horizon, and the other perpendicularly above it. The other two were in a line parallel to the horizon. Their shape was like that of a comet, the tail being from the moon. The side towards the moon was of a light orange colour. During the existence of these paraselenæ, a halo or luminous ring appeared round the moon in a circle, and passing through all the paraselenæ. At this instant two yellowish co-

loured lines joined the opposite paraselenæ, and formed four quadrants, by bisecting each other at the centre of the circle. A segment of another halo, concave upwards, seemed to touch the highest paraselenæ. All these appearances varied in brightness, and continued for more than an hour. A similar phenomenon was seen on the 2d. The mean temperature of these two days was — 30° and — 32½°, and the minimum temperatures — 34° and — 36°.

Paraselenæ of a similar kind were seen on the 1st January 1820, at 11 o'clock in the forenoon, and also on the 2d. The mean temperature of these two days was —18° and —24°, and the minimum temperature —28° and —29°. A drawing of the paraselenæ of January 1. is given by Captain Parry, p. 131.

Two parhelia were seen on the 8th March, one on each side of the sun, and at the distance of 21½°. The side nearest the sun was of a bright red colour, shading into orange and yellow. The mean temperature of that day was —18°, and the minimum temperature — 22°. A drawing of this meteor is given by Captain Parry in p. 156.

Various halos and parhelia were seen in the beginning of April, the mean temperature varying from — 6° to — 20°, but on the 9th April a remarkable one appeared, which continued from noon till 6 o'clock in the evening. "It consisted of one complete halo, 45° in diameter, and segments of several other halos; the most perfect of them was immediately above it, where more peripheries touched: the other segments were one on each side of the halo, not unlike parts of a rainbow, resting on the horizon; and two above it, that is, between it and the zenith. Besides these, *there was another complete ring* of a pale white colour, which went right round the sky, parallel with the horizon, and at a distance from it equally to the sun's altitude. Where this ring or circle cut the halo, there were two parhelia, and another close to the horizon, directly under the sun; this was by far the most brilliant of the parhelia, being exactly like the sun slightly obscured by a thin cloud at its rising or setting. I have always observed, when these halos or parhelia are seen, that there is a little snow falling, or rather small spiculæ or fine crystals of ice." A drawing of this parhelion is given by Captain Parry in p. 164.

On the 10th May 1820, at half past 10 A. M. Lieutenant Beechy observed a halo about the sun, with the arch of a second concave upwards, and touching the first at its vertical point, its centre being apparently about 40° or 50° from the point of contact. "There were two parhelia, faintly prismatic, as usual, *but about 3° without the circle.*" A drawing of this halo is given by Captain Parry, p. 172.

State of the Winds at Winter Harbour.—Upon examining the Meteorological Tables published by Captain Parry, it appears, that the predominating wind in these regions is that which blows from the North. This wind was also the coldest, which shews that the cold pole was to the north of Winter Harbour. In April, the wind from the SE. was observed to be the warmest. Whenever the wind rose, it invariably produced an increase of temperature; but the cold, though actually diminished in intensity, was always much more intolerable than in calm weather.

The first rain was observed on the 27th May, when every person run on deck to see it, as an astonishing phenomenon.

Hydrographical Observations.—Various observations were made on board the Hecla, upon the temperature and specific gravity of the sea water, both on the surface and at different depths, but the results which were obtained possess no peculiar interest. The temperature of the sea was always found to be colder at great depths than at the surface, which is quite the reverse of what was observed in the Spitzbergen Seas. See this Journal, vol. ii. p. 360.

The following experiments on the Increase of Weight experienced by different Woods, were made by Mr Edwards.

	Original Weight in grains.	Weight on coming to surface.	Increase of Weight.	Weight 3 hours afterwards.	Decrease in these 3 Hours.
Ash,	1425	2324 grs.	899 grs.	2291 grs.	33 grs.
Fir,	863	2112	1249	1964	148
Oak,	1421	2252	831	2201	51
Elm,	1220	2209	1079	2201	98

The following are the general results of the observations made on the Tides in Winter Harbour in 1820:

	Maximum Height. Feet.	In.	*Minimum.* Feet.	In.	Mean. Feet.	In.
May, -	4	2	0	10	2	6½
June, -	3	7	1	4	2	7
July, -	3	9	1	5	2	8½

The times of High Water on full and change days of the moon in Winter Harbour were as follows:

New Moon,	May 12. 1820,	-	$1^h 15'$
Full,	—— 27. ——	-	1 45
New,	June 10. ——	-	1 15
New,	July 10. ——	-	1 40
Mean time of high-water on full and change,			1 29

Experiments with the Pendulum.—As a full detail of these experiments will be published in the *Philosophical Transactions* for 1821, Captain Sabine has given only a brief statement of the results, which are as follows:

From the Acceleration between	Diminution of Gravity from the Pole to the Equator.	Ellipticity of the Earth.
London and Brassay, - -	·0055066	$\frac{1}{314,3}$
London and Hare Island, -	·0055139	$\frac{1}{313,6}$
Brassay and Hare Island, -	·0055082	$\frac{1}{314,2}$
London and Melville Island, -	·0055258	$\frac{1}{312,6}$

Audibility of Sounds.—Captain Parry was surprised at the great distance at which sounds were heard in the open air, during the continuance of intense cold; and, notwithstanding the frequency with which they had occasion to remark it, it always afforded them surprise. "We have, for instance," says he, "often heard people distinctly conversing, in a common tone of voice, at the distance of a mile; and to-day I heard a man singing to himself as he walked along the beach, at even a greater distance than this."

As Captain Parry does not seem to be aware of the cause of this very curious and important fact, we shall endeavour to explain it, upon principles which Humboldt has ably developed, in a paper on the Increase of Sounds during Night, (See this Journal, vol. iii. p. 194.) If the air were at all times of uniform density, the sounds propagated through it would always be of the same intensity; but in the day time, the inequality with which different parts of the ground are heated occasions a difference of density in the adjacent air, and thus

produces undulations of different density, by which the sonorous undulations are divided and interrupted, in the same manner as light is in passing through alcohol and water imperfectly mixed, or any medium of heterogeneous density. Now, at Winter Harbour, the temperature of the ground and that of the air near it had a wonderful degree of uniformity. The absence of the sun prevented any difference of density arising from the unequal heating of the ground; and consequently, the mass of air, above a mile long, which, on the 11th February, intervened between Captain Parry and the sailor whose song he heard through that interval, was perfectly homogeneous, and offered no obstruction to the undulations which the voice of the sailor had propagated through it. In proof of this opinion, we have only to look at the temperature for that day, and we shall find, that the maximum and minimum temperatures were —38° and —42°, and the mean 39°.77; the whole range of temperature for that day being only 4°! which is a satisfactory proof of the perfect homogeneity of the strata of air incumbent on the ground.

ART. XXX.—*Analysis of Sulphate of Nickel and Copper.* By ANDREW FYFE, M. D., Lecturer on Chemistry, Edinburgh. Communicated by the Author.

THE salt, which is the subject of the following paper, was given to me for analysis, by Dr Brewster, in consequence of his having found it to possess only *One* axis of double refraction, contrary to the general law which he had established, that all sulphates with a single base (and among these certain crystals of sulphate of nickel) have *Two* axes of double refraction*.

The salt was entirely soluble in water, forming a green solution. When nitrate of baryta was added to the solution, a white precipitate fell, which was insoluble in nitric acid. Ammonia threw down a greenish powder, soluble in excess of the alkali, and the fluid acquired a blue colour. On the addition of prussiate of potassa, a precipitate, partly of a greenish, part-

* See this Number, p. 6.

ly of a brownish colour appeared. It was this that led me to suspect the presence of copper, a suspicion which was confirmed by other experiments; thus, when a solution of sulphuretted hydrogen was added to that of the salt, a black powder fell, which, when dissolved in nitric acid, afforded a blue precipitate with the ammonia, soluble in excess of the alkali, and yielded also a brown precipitate with the prussiate of potassa. The fluid from which the black powder was thrown down, gave a greenish precipitate on the addition of ammonia, which disappeared on adding more of the alkali, converting the colour of the fluid to blue.

These experiments indicate the presence of sulphuric acid, nickel, and copper, which, with water of crystallization, are the only substances I could detect in the salt. That this is its composition, is also confirmed by the analysis, made with the view of ascertaining the proportion of its ingredients, in which I employed sulphuretted hydrogen as the means of separating the copper from the nickel; the latter not being precipitated by this substance.

Ten grains of the salt were exposed to a gentle heat, till the whole of the water of crystallization seemed to be driven off, after which they weighed 7.05 grains, making the loss 2.95.

When sulphate of nickel is subjected to a high temperature, it undergoes a slight decomposition, and a small portion of insoluble subsulphate is formed. The saline matter left, after the exposure of the ten grains of the salt to heat, in the above experiment, was entirely soluble in water, proving that decomposition had not taken place.

The white precipitate occasioned by nitrate of baryta, after exposure to a red heat, weighed $7.52 = 2.55$ of sulphuric acid.

The black powder thrown down by sulphuretted hydrogen, after exposure to heat, was dissolved in nitric acid, and then afforded, with potassa, a precipitate, weighing $0.53 =$ oxide of copper. To the fluid from which the copper was removed, potassa was added; the precipitate weighed $3.95 =$ oxide of nickel. The component parts of the salt, then, according to this analysis, are,

Water of crystallization,	2.95	or	29.5
Sulphuric-acid,	2.55		25.5
Oxide of nickel,	3.95		39.5
Oxide of copper,	0.53		5.3
	9.98		99 8
Loss,	2		2
	10.00		100.0

The slight deficiency, I have no doubt, is in the water of crystallization, for as I was afraid that, by exposing the salt to too strong a heat, it would undergo decomposition, the whole of this substance may not have been driven off. The following, therefore, I consider to be the true composition of the salt.

Water of crystallization,	29.7
Sulphuric acid,	25.5
Oxide of nickel,	39.5
Oxide of copper,	5.3
	100.0

Considering the proportions in which the ingredients exist in this substance, I am induced to regard it as a peculiar triple salt; and that the copper is not merely accidentally mixed with the sulphate of nickel; for if we combine the oxide of the former metal with its due quantity of sulphuric acid, we shall find that there is not enough of this acid left to saturate the oxide of the latter. Sulphate of copper is generally stated to be composed of 31.38 of acid, and 32.32 of oxide, with water of crystallization; 5.3 of oxide, therefore, take 5.1 of acid, leaving 20.4. In sulphate of nickel, according to Thomson, 25.6 of oxide are united with 28.98 of acid, 39.5 of the former then acquire 45.13 of the latter, but there are left only 20.4. Leaving even the copper out of consideration, there is not enough of acid to saturate the oxide of nickel, according to the constitution of the sulphate of this metal, as stated above; besides, in the salt, the analysis of which has been given, the water of crystallization is far inferior to what it is in sulphate of nickel, as in the latter it amounts to about 45 in the 100 parts.

EDINBURGH,
June 1821.

Art. XXXI.—*Proceedings of the Cambridge Philosophical Society.*

March 5. 1821.—*Analysis of Native Phosphate of Copper from the Rhine.* By the Rev. F. Lunn, B. A. F.R.S. F.C.P.S. St John's Coll. Camb.—Doubts have existed of the accuracy of Klaproth's analysis (the only one yet given,) of this exceedingly rare mineral, and these receive much confirmation, from a considerable quantity of combined water being entirely overlooked. In this paper, some analytical difficulties which occur in the separation of phosphoric acid are examined. The method which appears to agree best with experiments of verification, is to obtain an insoluble phosphate, by the addition of perfectly neutral nitrate of lead. The result obtained by Mr Lunn was,

	Experiment.	Atoms.	Theory.
Phosphoric acid, -	21.687	1	22.222
Per-oxide of copper, -	62.847	1	63.492
Water, - -	15.454	2	14.285

Hence its chemical symbol is, - $\ddot{C}u\,\ddot{P} + 2\,Aq$

and its mineralogical - - - $CuP + 2Aq$

Dr E. D. Clarke, Professor of Mineralogy, read a paper on the Crystallization of Water, as it was remarkably developed in Cambridge, January 8. 1821, and two following days; the crystals being of considerable magnitude, and of the rhomboidal form, measuring in their obtuse angles 120°. This form the Professor considered as exhibiting the primitive form of *hydrogen-oxide;* because the disposition of the laminæ in those crystals was evidently parallel to the plane faces of the rhombi.

March 19.—*On Arragonite.* By Dr E. D. Clarke.—This paper proposed to explain the cause of the different specific gravities of the several varieties of this mineral; and proved, that the famous Egyptian Soros, discovered by Mr Belzoni in Upper Egypt, which has been considered as of Oriental alabaster, is one integral mass of stalactitic arragonite.

April 2.—A communication from Professor Leslie, F.R.S.E., and Hon. Mem. of the Cam. Phil. Soc., was read, detailing some experiments made upon Sound excited in hydrogen gas; from

which it appeared that the effect was considerably less than what would be produced in atmospheric air of the same density. The cause appears to depend partly on the tenuity of hydrogen gas, and partly on the rapidity with which the pulsations are conveyed through this very elastic medium.

On the Connection between Galvanism and Magnetism. By the Rev. J. Cumming, M. A. F. R. S., Professor of Chemistry. —Before reading his paper, the Professor repeated the electro-magnetic experiments of Professor Oersted, in presence of the Society. The first part of the paper contained an account of the effects of a wire connecting a large Zinc and Copper plate, on two magnetic needles, one moving horizontally, the other vertically; the connecting wire being bent into the form of a circle, and the needles applied to it at different azimuths. The direction of the galvanic current was shewn to be such, that a wire connecting the zinc and copper-plates tended to place itself at right angles to the magnetic meridian, which appeared experimentally, by suspending a pair of very small plates. An instrument was then described for detecting weak galvanic action, by its effects on the magnetic needle. It was found that the magnetic influence could not be transmitted between a pair of plates through any non-metallic medium; but, on making the circuit through a tube filled with acetate of lead, the needle began to be affected, when the arborescence of the revived lead had formed the metallic connection. On using connecting-wires of different lengths and diameters, it appeared that the magnetic influence was transmitted through large wires, though of considerable length, provided they were solid, more readily than through small ones, however short. An analogous effect was found to be exhibited on connecting the poles of a magnet by pieces of iron, of different lengths and thickness. The paper was concluded by contrasting this analogy with the opposite effects observed in the transmission of common electricity.

May 7.—On the Geology of the Lizard. By the Rev. A. Sedgwick, M. A. F. R. S. F. C. P. S., Woodwardian Professor. —In the early part of this paper, the Professor gave a short description of the external appearance of the country, as far as it appeared to be connected with its mineral structure. He then entered into details respecting the phenomena presented by

the several parts of the coast between the Helford river and Loe-Bar. From a general review of the facts presented on both sides of the promontory, he concluded, that a section made from the heights above Constantine to the mouth of the Helford river, and from thence to Old-Lizard-Head, would exhibit a series of formations nearly in the following order:

1. Granite, containing an excess of mica at its junction with the slate.

2. Clay-slate.

3. Clay-slate, associated with greywacke-slate, and containing subordinate beds, in which were a coarse conglomerate, common greywacke, and fine grained sandstone.

4. Serpentine, surmounted by granular diallage-rock, and amorphous greenstone, pàssing into greenstone-slate.

5. An extensive porphyritic formation, composed of diallage and hornblende.

6. Nearly compact masses formed of the same constituents, associated with a very large-grained diallage-rock, and alternating with serpentine.

7. Serpentine, irregularly associated with saussurite, diallage-rock, greenstone-porphyry, greenstone-slate, and granular felspar; the several parts rarely presenting any appearance of stratification or order of superposition.

8. Greenstone-slate.

9. A formation apparently interlaced with both greenstone-slate and serpentine, and composed of chloritic-slate, (in one place associated with thin beds of mica-slate,) talcose-slate, and felspathic-slate.

By way of conclusion, he endeavoured to identify the serpentine of the lizard with some foreign formations which appear among transition-rocks.

On a remarkable peculiarity in the law of the extraordinary refraction of differently-coloured rays, exhibited by certain varieties of Apophyllite. By J. F. W. Herschel, Esq., F. R. S. Lond. & Edin. F. C. P. S., &c. Fellow of St John's Coll.—In a former paper, Mr Herschel had instanced some remarkable deviations from the ordinary law of tints exhibited by certain specimens of this substance. Upon reconsidering his results, it appeared that these specimens could not be referred exclu-

sively either to the class of attractive or of repulsive double-refracting crystals, nor to the intermediate class, which is devoid of the property of double refraction. They appeared to belong at once to all the three classes of media just mentioned; possessing the property of attractive crystals, when exposed to the rays, forming one extreme of the spectrum, and of repulsive in their action on the other extreme; while for certain intermediate rays they were altogether devoid of the property of double refraction. Mr Herschel was led to this inference, by observing that the curves, whose ordinates represented the polarizing energy, after approaching very rapidly to the axis, would again recede rapidly from it on the same side, except the ordinates were supposed to become negative, which appeared more probable. This induced him to examine the truth of his supposition, by measures taken in homogeneous light, and the result was a complete confirmation of the remarkable singularity above noticed.

May 21.—*On the application of Magnetism as a Measure of Electricity.* By the Rev. J. Cumming, F. R. S. F. C. P. S., Professor of Chemistry.—After mentioning the difficulties in applying the decomposition of water or the fusion of wires, either as tests or as measures of galvanism, the instrument described in a former paper by Professor Cumming, was shewn to be capable of detecting the galvanism developed by two surfaces not greater than the $\frac{1}{500}$th of an inch, and was applied to discover the galvanic action of different metallic surfaces and fluids; amongst others of zinc and potassium, and of strong and dilute sulphuric-acid. A galvanometer was described, consisting of a connecting-wire moveable upon a graduated slide. By comparing the deviations of a needle placed below it at different distances, the tangent of the deviation was found to vary inversely as the distance of the connecting-wire from the magnetic needle. On applying the deviation produced on the magnetic needle as a measure of the increased effect produced by moving two galvanic surfaces towards each other, it appeared that the tangent of the deviation varied inversely as the square root of the distance of the plates from each other. The latter part of the paper consisted of a detail of miscellaneous experiments. A steel-wire was made permanently magnetic, by twist-

ing it round a straight connec ting-wire. A horse-shoe magnet was placed in the circuit, by twisting a wire from right to left round one pole, and from left to right round the other; on connecting it alternately with each end of the battery, the magnetism of one pole was destroyed, when that of the other was increased. On transmitting the galvanism from a pair of plates of $1\frac{1}{2}$ feet of surface through a copper globe of 4 feet surface, the magnetic influence was distributed over every part, both of the globe and of the plates themselves. The paper was concluded with some remarks on the probable insight into the laws of galvanic agency, to be hoped for from the application of the newly discovered connection between magnetism and galvanism.

On a Regulator to equalize the Velocity of Machinery. By the Rev. William Cecil, M. A. F. C. P. S., Fellow of Magdelene.—If two wheels be so connected that the velocity of one being increased, that of the other shall be increased in the *same* ratio; and if these wheels be also connected, so that the velocity of the first being increased, that of the other shall be increased in a *higher* ratio; it will be impossible that any increase at all should take place, because it would require the second to move with two different velocities at once. These conditions may be fulfilled by connecting the wheels in the first place by common teeth-work, and in the next place by another toothed wheel which slides into different positions as the centrifugal force varies. By this means Mr Cecil obtains a regulator which opposes no resistance up to a certain velocity, but which, beyond that point, opposes an insurmountable resistance to all increase of velocity; and which can be easily combined with any revolving machine, of whatever power and construction, whose rate of going it may be desirable to equalize.

May 22.—The Society held its second anniversary meeting, at which the following Officers were appointed for the ensuing year:

President.—Dr Wood, Dean of Ely, Master of St John's College.

Vice-President.—Dr E. D. Clarke, Professor of Mineralogy.

Treasurer.—Rev. B. Bridge, B. D. F. R. S., Fellow of Peterhouse.

Secretaries. Rev. G. Peacock, M. A. F. R. S., Fellow of Trinity. J. S. Henslow, M. A. F. L. S., St John's.

Council. Dr Thackeray, *Emmanuel*; Professor Cumming; Professor Lee; Rev. R. Gwatkin; Rev. T. Hughes, *Emmanuel*; Rev. T. Chevalier; Mr Whewell.

Art. XXXII.—SCIENTIFIC INTELLIGENCE.

I. NATURAL PHILOSOPHY.

ASTRONOMY.

1. *Heat discovered in the Moon's Rays.*—The following interesting experiment was made by Dr Howard, by means of a differential thermometer of his own invention, (see this *Journal*, vol. ii. p. 383.) " Having blackened the upper ball of my differential thermometer, I placed it in the focus of a 18 inch reflecting mirror, which was opposed to the light of a bright full moon. The liquid began immediately to sink, and in half a minute was depressed 8°, where it became stationary. On placing a skreen between the mirror and the moon, it rose again to the same level, and was again depressed on removing this obstacle." This experiment was repeated several times, in presence of some of Dr Howard's friends, and always with the same result. See Silliman's *American Journal*, vol. ii. p. 329.

2. *On the supposed Transit of the Comet of* 1819 *over the Sun.*—We have already stated, (see this *Journal*, vol. ii. p. 379.), that General Lindener could see no spot on the sun on the 26th May 1819; but it appears from the observations of Professor Schumacher and Brandes, that the sun was by no means free from spots on that day; and Dr Gruithuisen and Professor Wildt agree in describing a small spot near the middle of the sun's disc, which might possibly have been the comet, though certainly not so distinctly defined as a planet would have been. Bode's *Jahr.* 1823.

3. *Volcanoes in the Moon.*—Dr Olbers informs Dr Gauss, that he observed on the 5th February an appearance in the dark part of the moon, which has been called a lunar volcano, (see this *Journal*, vol. iv. p. 429.) It appeared as usual in Aristarchus. It was small, but much brighter than the other parts of the moon, unilluminated by the sun, quite like a star, and even appeared like a star of the sixth magnitude, seen situated to the north-east of the moon. Dr Olbers is inclined to believe that this brightness is produced by the reflection of the light of the earth from an even and smooth surface of a great extent of rock in the moon. If it shall be found that the same

luminous point always appears in the same libration of the moon, the opinion of Dr Olbers will become highly probable.

OPTICS.

4. *Optical Properties of Euclase.*—In the summer of 1820, Mr Brooke was so kind as to send me a fine specimen of this rare mineral for optical examination. I found it to have Two axes of double refraction, as I had predicted in 1817 from its primitive form, (*Phil. Trans.* 1818, p. 225.) The principal axis, which is *Positive*, is coincident with no line in the primitive form of the crystal, as is the case in *Sulphate of Lime*, *Kyanite*, and *Tincal*, and the neutral axes do not coincide (as happens in kyanite and tincal) with the axes of the rhomboidal prism in which it crystallises. This property, so uncommon in crystallised bodies, indicates some peculiarity in the structure of these minerals, of which crystallographers are not aware.—D. B.

5. *A new Primitive Form detected in Boracite.*—In a paper recently laid before the Royal Society of Edinburgh, Dr Brewster has shewn that *Boracite* possesses a new primitive form, which has not been recognised by crystallographers, viz. the *Rhombohedral Cube*, or the *Cube with one axis*, which forms the limit between the acute and the obtuse rhomboids. This result was deduced from the fact, that Boracite has *One* positive axis of double refraction, coincident with one of the diagonals of the solid, or the axis of the rhomboidal cube.

6. *Distribution of the Colouring Matter in Topaz.*—In a series of experiments on the distribution of the colouring matter in topaz, laid before the Royal Society of Edinburgh at its last meeting, and forming a continuation of the experiments given in the *Phil. Trans.* 1819, p. 11. Dr Brewster has shewn, that in several specimens of the Yellow Brazil Topaz, the inclination of the resultant axes is in general about 50° 5′, and sometimes less, whereas in the Blue Topaz of Aberdeenshire, and the Colourless Topaz of New Holland, it is about 65°. But what is very remarkable, the one resultant axis is inclined only 22° 37′ to the axis of the prism, while the other is inclined 27° 28′; so that the principal axis of double refraction in the Yellow Brazil Topaz is not perpendicular to the surface of the laminæ. Specimens of these different minerals have been sent for analysis to an eminent foreign chemist, in the confidence that they are different substances, differing probably in the quantity of Fluoric Acid.

7. *Optical Properties of Leucite or Amphigene.*—Dr Brewster has also succeeded in separating the two images formed by the double refraction of Amphigene, and has ascertained that it has *Two axes.* It cannot, therefore, have the cube with either one or three axes as its primitive form. The circumstance of Haüy having assigned to it two primitive forms, viz. the cube and the rhomboidal dodecahedron, points it out as a remarkable mineral. It must now take its place under the Prismatic system of Mohs.

8. *Aërial Shadows seen from the Summit of Ben Lomond.*—On the 19th of August 1820, Mr Menzies, surgeon, Glasgow, and Mr Macgregor, began to ascend the mountain from Rowardennan, about five o'clock afternoon. They had not proceeded far till they were overtaken by a smart shower; but as it appeared only to be partial, they continued their journey, and by the time they were half way up, the cloud passed away, and a most delightful afternoon succeeded. Thin, transparent vapours, which appeared to have risen from the lake beneath, were occasionally seen floating before a gentle and refreshing breeze: in other respects, as far as the eye could trace, the sky was clear, and the atmosphere serene. They reached the summit about half past seven o'clock, in time to see the sun sinking beneath the western hills. Its parting beams had gilded the mountain tops with a warm glowing colour; and the surface of the lake, gently rippling with the breeze, was tinged with a yellow lustre. While admiring the adjacent mountains, hills and valleys, and the expanse of water beneath, interspersed with numerous wooded islands, Mr Macgregor's attention was attracted by a cloud in the east, partly of a dark red colour, apparently at the distance of two miles and a half, in which he distinctly observed two gigantic figures, standing, as it were, on a majestic pedestal. He immediately pointed out the phenomenon to Mr Menzies, and they distinctly perceived one of the gigantic figures, in imitation, strike the other on the shoulder, and point towards us. They then made their obeisance to the airy phantoms, which was instantly returned: they waved their hats and umbrellas; the shadowy figures did the same. Like other travellers, they had carried with them a bottle of usquebaugh, and amused themselves in drinking to the figures, which was of course duly returned. In short, every movement which they made, they could observe it distinctly repeated by the figures in

the cloud. This phenomenon continued at least for about a quarter of an hour. A gentle breeze from the north carried the cloud in which it appeared slowly along; the figures became less and less distinct, and at last vanished.

METEOROLOGY.

9. *Mean Temperature of Leadhills for Ten years.*—Elevation 1280 feet above the level of the sea. Average of observations of the temperature made twice a-day; one at six in the morning, and another at one in the afternoon, at the Scots Mining Company's counting-house.

1811.		1812.	1813.	1814.	1815.	1816.	1817.	1818.	1819.	1820.
Jan.	30°	33°	32½°	23½°	30°	35½°	36°	34¼°	35½°	29½°
Feb.	34½	35	36½	32	39	32	37½	32	34	35½
Mar.	41	33	40	36½	39	34½	36	35	42	38
April,	46½	37½	42	47½	43	40	42	40	44	47
May,	51½	48½	49½	46	53	48½	47	52	50½	50
June,	56	53	55½	52	56	54	57	60	53	54
July,	58	55	57½	58	56	54	55	60½	59	59
Aug.	53	54	54	55	55½	53	53	55	61½	55½
Sept.	52	51	48½	51½	51	48½	51	51	50½	50
Oct.	48	41½	42	44	45	47	42	49	41	41
Nov.	41	36	36	35½	32½	35½	43	45	34	36½
Dec.	31½	32	37	32½	33	32½	32	36	29½	37
	42.25	42.46	44.25	42.83	44.42	42.92	44.29	45.83	44.54	44.42
MEAN TEMPERATURE for Ten Years, 44°.121.										

If we adopt with Humboldt 656 feet as the altitude which produces a variation of 1° of Fahrenheit, we shall have 1°.95, corresponding to 1280 feet; and therefore,

Observed Temperature of Leadhills, - - - -	44°.121
Add for 1280 feet of elevation, - - - - -	1.95
Reduced to Level of the Sea,	46.071
Mean Temp. of Leadhills, according to Dr Brewster's formula, (Lat. 55° 25′), - - - - -	46.26
Difference,	0.189
The Temperature of the Springs at Leadhills is - -	44°

	Lowest Temp. observed.		Highest observed.			Lowest Temp. observed.		Highest observed.	
1811,	Jan.	15°	July,	76°	1816,	Jan.	14°	June,	72°
1812,	Dec.	16	June,	72	1817,	Mar.	13	June,	79
1813,	Mar.	17	June,	75	1818,	Feb.	—16	July,	77
1814,	Jan.	6½	July,	74	1819,	Dec.	—12	Aug.	77
1815,	Jan.	12½	June,	76	1820,	Jan.	8½	June,	75

10. *Quantity of Rain which fell at Leadhills from* 1813 *to* 1820.—The following Table shews the quantities of rain which fell at Leadhills from the end of March to the beginning of November, measured by a guage, in the garden of Mr Irving's house, for the years 1813 to 1820 inclusive.

	1813.	1814.	1815.	1816.	1817.	1818.	1819.	1820.
April,	Not ob.	6.67	1.90	1.98	0.61	3.37	Not ob.	2.08
May,	5.10	0.93	6.20	3.91	5.01	1.66	3.09	7.80
June,	2.12	2.97	3.52	2.65	3.10	4.52	6.13	4.18
July,	4.32	4.85	2.99	5.13	5.15	6.31	2.80	3.07
August,	1.68	6.03	7.76	3.43	7.28	2.64	2.43	8.83
September,	5.23	4.12	8.99	7.21	3.25	7.05	4.22	4.61
October,	4.73	6.04	7.38	4.57	2.00	7.48	7.90	4.04
		31.61	38.74	28.88	26.40	33.03		34.61

The guage was taken in during winter; and the rain which fell in April 1813 and 1819 was not observed, as Mr Irving was not at Leadhills these years till after this month had begun. The largest quantity observed to fall within twenty-fours was 2.56 inches, which fell betwixt two in the afternoon of the 25th September 1815, and nine in the morning of the 26th. 1.22 in. had fallen on the 22d of the same month.

11. *On the Temperature of the German Ocean.*—The following observations on the temperature of the German Ocean were made by Mr John Murray:

1821,		Temperature.
Feb. 22.	Seven miles off *Huntley Foot*, (River Tees), depth 40 fathoms, at 10h 30′ A. M. - - - -	Fahr. 42°
	Four miles off *Red Cliff*, (to southward), depth, say 35 fathoms, at 10 o'clock P. M. - - - -	40.75
	Three miles off *Whitby*, depth 28 fathoms, at 4h 22′ A. M.,	41
Feb. 23.	Two miles off *Kelsey*, depth 7 fathoms, at 8 o'clock A. M.,	37.5
	Two miles off *Spurn Lights*, depth 7.25 fathoms, at 9h 22′ A. M., - - - - - -	38
	Three miles off *Spurn Lights*, *mouth of the Humber*, depth 7 fathoms, at 10 o'clock P. M., - - -	38
Feb. 24.	*In the Humber*, three miles from Hull, at 9 o'clock A. M.,	35.75

MAGNETISM.

12. *On the Effects of Magnetism on Chronometers.*—We understand that, in consequence of the paper published in the last volume of the Philosophical Transactions, relative to the action of a ship's iron on the rate of chronometers, (See this *Journal*, vol. iv. p. 199.) Mr Barlow of the Royal Military

Academy has undertaken a course of experiments, with a view to reduce to some law this new impediment to the perfection of the art of navigation. The first course of experiments, which were carried on at the observatory of his friend the Reverend Mr Evans, is completed, and has given rise to many curious results: a new course is now going forward at the Royal Military Academy, but the experiments are too little advanced to say what new deductions can be made from them. In the first course, it appears that four out of the six chronometers employed, decidedly lost on their rates in every position near the iron, amounting in some cases to 4″ or 5″ *per* day. One chronometer seems to have gained in every position, and another was scarcely affected in its rate in a perceptible manner. Mr Barlow has ascertained that the power of the magnet in this case, as in his former experiments, resides wholly on its surface. We hope to be able to give a more particular account of these experiments in our next Number.

13. *Effect of Position on Magnetic Masses.*—In vol. i. p. 242. of this Journal, we have mentioned the facts on this subject noticed by Colonel Gibbs. Sir Charles Giesecké observed similar effects in Greenland. All the basalt of Disco Island is magnetic. That which is found in the most elevated situations is most so, the fallen masses dispersed around the base of the mountains having more power over the needle than the others.

HYDRODYNAMICS.

14. *Water Velocipede.*—An exhibition, improperly called *walking on the water*, has been exhibited in Scotland by Mr Kent. The apparatus which he uses is represented in Plate I. Fig. 18. where *a*, *b*, *c*, are three hollow tin-cases of the form of an oblong hemispheroid, connected together by three iron bars, at the meeting of which is a seat for the exhibitor. These cases, filled with air or some gas, are of such a magnitude that they can easily support his weight; and as *ab* and *ac* are about ten feet, and *bc* about eight feet, he floats very steadily upon the water. The feet of the exhibitor rest on stirrups, and he attaches to his shoes, by leather-belts, two paddles, *d*, *e*, which turn round a joint when he brings his foot forward to take the stroke, and keep a vertical position when he draws it back against the resisting water. By

the alternate action of his feet, he is enabled to advance at the rate of five miles an hour.

15. *Method of keeping off the Back-Water from Mills.*—In our last Number, p. 439. we have described, after Mr Perkins, the contrivance for this purpose which has been used in America for several years. We are informed by a learned correspondent, that it was invented by our countryman Mr Burns, a well known and ingenious mechanic, so far back as 1794, and was, to a certain extent, put in practice the following year by the late Mr George Meikle, mill-wright, on two water-wheels at Cartside in Renfrewshire.

II. CHEMISTRY.

16. *On the Solution of Phosphorus in Sulphuret of Carbon.*—It is known that phosphorus is eminently soluble in sulphuret of carbon, but, as far as I know, the triple compound has not been investigated. I have instituted a few experiments upon it. It appears to be a true triple chemical compound, and the term *Sulpho-carburet of Phosphorus* seems appropriate. The compound remains still fluid, with increase of density and of refractive power. It is altered by light. This compound frequently inflames spontaneously. Its combustion takes place at a temperature below 80° Fahrenheit. It bursts into flame on contact of a few crystals of iodine. An instantaneous flame appears when immersed into chlorine. It diffuses through oxygen, and explodes on contact of flame. The smallest portion, triturated with some crystals of oxymuriate of potassa, detonate with great violence. A few crystals of oxymuriate of potassa, and a small portion of this compound, are ignited by a drop of sulphuric acid. When a small portion of it, on a slip of paper, was introduced into nitrous oxide, it exploded on contact of flame, and then burnt calmly; and when a bit of copper-foil was moistened with it, and plunged into the same medium, it detonated on contact with flame, and an ignited jet burst from the cylinder. This fluid, on being dropped into nitrous acid, effervesced, became transparent, surrounded by an opaque ring, and when removed, was opaque, solid, and crystalline. When in contact with nitrous acid, it is inflamed by a drop of sulphu-

ric acid. When a thin slice of hydrophane, of an elliptic form, was placed in a tube containing sulphuret of carbon, and viewed diagonally, it exhibited the appearance of a molten mirror, encircled by an opaque rim or annulus.

17. *Dr Henry on Coal and Oil Gas.*—In a very able paper "On the Aeriform Compounds of Charcoal and Hydrogen," by Dr Henry of Manchester, which will appear in the Phil. Trans. for 1821, the following results are given:

1. That carburetted hydrogen-gas must still be considered as a distinct species, requiring for the perfect combustion of each volume two volumes of oxygen, and affording one volume of carbonic acid; and that if olefiant-gas be considered as constituted of one atom of charcoal, united with one atom of hydrogen, carburetted hydrogen must consist of one atom of charcoal in combination with two atoms of hydrogen.

2. That there is a marked distinction between the action of chlorine on olefiant gas, (which, in certain proportions, is entirely independent of the presence of light, and is attended with the speedy condensation of the two gases into chloric ether,) and its relation to hydrogen, carburetted hydrogen, and carbonic oxide gases, in all which it is inefficient, provided light be perfectly excluded from the mixture.

3. That since chlorine, under these circumstances, condenses olefiant-gas, without acting on the other three gases, it may be employed in the correct separation of the former from one or more of the three latter.

4. That the gases evolved by heat from coal and from oil, though extremely uncertain as to the proportions of their ingredients, consist essentially of carburetted hydrogen, with variable proportions of hydrogen and carbonic oxide; and that they owe, moreover, much of their illuminating power to an elastic fluid which resembles olefiant-gas in the property of being speedily condensed by chlorine.

5. That the portion of oil-gas and coal-gas which chlorine thus converts into a liquid form, does not precisely agree with olefiant-gas in its other properties; but requires for the combustion of each volume nearly two volumes of oxygen more than are sufficient for saturating one volume of olefiant-gas, and affords one additional volume of carbonic-acid. It is probable,

therefore, either a mixture of olefiant-gas with a heavier and more combustible gas or vapour, or a new gas *sui generis*, consisting of hydrogen and charcoal, in proportions that remain to be determined.

18. *Dr Ure's Dictionary of Chemistry on the Basis of Mr Nicholson's.*—This work has been now some months before the public, and its reception has been so favourable, as to supersede the necessity of any minute detail of its composition and merits. The compilation of Nicholson, on whose basis the present Dictionary is founded, had become in a great measure obsolete, in consequence of the multitude of important discoveries made within the last twelve years; and though Dr Ure seems to have been engaged merely to re-edite that old work, and insert occasional notices of recent improvements, he has wisely consulted his own reputation, in re-writing the greater part of the volume, which, from the style of its typography, is equivalent to at least three ordinary octavos. Indeed, the articles Caloric, Coal-gas, Combustion, Dew, Electricity, Equivalents Chemical, Gas, Light, inserted by the Doctor, may be regarded as more copious and elaborate dissertations on these leading subjects, than are to be found in any preceding chemical compilation. He appears to have taken laudable pains in ascertaining the facts which form the solid substratum of the science; and though the practical nature of his work precluded much historical research, he has shewn in his articles Acid, Alkali, Chlorine, Congelation, Electricity, and Iodine, that many mistakes remain to be rectified with regard to the progress of discovery.

III. NATURAL HISTORY.

MINERALOGY AND GEOLOGY.

19 *Buckland on the Structure of the Alps.*—Professor Buckland has just published in the Annals of Philosophy an extensive notice of a memoir on the structure of the Alps, which we regret has reached us too late for particular notice in our present Number. We shall take it up in our next. In the mean time, we may remark, that the statements are of a most interesting nature, and that the whole does infinite honour to the judgment of this active and enterprising geologist.

20. *Structure of Crystals.*—Recent investigations having directed the attention of observers in a particular manner to the study of the optical characters of crystallised minerals, we think it may not be without use to notice a circumstance in the structure of crystals, which, if not known, or neglected, may lead into error. Many crystals, which, in a general view, appear simple, are found to be compound, when all their relations are attended to; and these, when examined optically, will present a *compound* in place of a *simple* structure. The simple structure characterises the Species of minerals, while the compound structure often distinguishes the Variety or subspecies.

ZOOLOGY.

21. *Notices relating to the Nightingale.*—"The nightingale, (Motacilla luscinia,) so justly famed for its enchanting song, does not visit this northern part of England so frequently as it did forty or fifty years ago; this is a fact agreed upon by all persons, to whom I have made application on the subject, and who have noticed the arrival, and other particulars relative to this bird. Whatever may be the cause, it is confessedly seldom heard in this part of the island. I well recollect going, about eighteen years ago, when I was a boy, to a small coppice at a short distance from my paternal roof, to listen to the dulcet notes of this nightly warbler:—from that time to the present year I had never heard it, till the 9th June last, in the evening of which day it was heard, at a short distance from my residence; and for several successive evenings, I heard it even before retiring to rest, or, as I reposed on my bed, I believe at every intermediate hour from eleven to three. I strongly suspected its nest was in a small thicket, composed of hawthorn, laburnum and filbert bushes, situated at one end of my garden, as I often saw the bird there, particularly in the evenings about sunset, when it began some slight chirping, but retired generally to the NE. by E., to a thick and high hawthorn hedge, and occasionally to NW., or near that point, in the same hedge where it always sung. The two diverging lines from the thicket to its station, forming

very nearly a right angle, I fancy the wind blowing from different points of the compass, might be the cause of the bird's choosing those different parts of the hedge for its nightly station, in order that the sound of its voice might be borne by the gentle breeze, to the hen-bird during the time of incubation. I did not find the nest in the thicket, being unwilling to disturb so rare a visitant; indeed it would not perhaps have been easily practicable, as the place in the thickest part is not very accessible, overhanging an old stone-quarry. I frequently observed the nightingale in the day time perched in the thicket, and also noticed that it often carried thither insects, &c. most probably for the support of the female during her confinement; as the male-bird does not sit on the eggs at all. One fine evening, just after-sunset, I approached near the thicket as silently as possible, and, standing under the shade of a Syringa bush, I began to play upon a flute very softly the beautiful air by Pleyel, known by the name of the "German Hymn;" and at the same time a pupil of mine stood in such a situation as to have a pretty distinct view of the thicket. I had scarcely got through the air, when the nightingale was heard to chirp, and, during the second time of my playing it, my young friend saw it hop through the bushes with great celerity towards the place where I stood, at the same time making a sort of sub-warbling, which it soon changed into its usual melodious and lengthened song; but, on my companion's speaking to me, it immediately heard, and most probably observed him, as he immediately saw it fly to the hedge in which it was wont to sing. I regret much it was disturbed, as I have no doubt but the sound of the flute had at that time excited it to sing, as it was never known to do so *there*, either before or after that time. (It is said, and I believe truly, that the nightingale never sings very near its nest.) Both the places in the hedge in which it sung were about 110 to 120 yards from the thicket, and from 40 to 50 from my door. A goldfinch (Fringilla carduelis,) which had been taught several peculiar notes, was two or three times hung up in a cage in the thicket; it was singular and amusing to hear the nightingale endeavour to imitate the goldfinch, which it would sometimes do, mixing with its imitations its native notes. I could never observe that it approached the cage, as other small birds

did, when the goldfinch was calling. It at all times appeared peculiarly timid. About the middle of July much rain fell here, after that time I neither saw nor heard the plaintive warbler, which had, nightly, for about five weeks, serenaded us with his matchless song."—*Letter from Mr Johnson, Hill Top, near Wetherby.*

22. *Analysis of one of the Vertebræ of the Orkney Animal.*—Dr Leach of the British Museum, a considerable time ago, communicated to the Wernerian Society, the following analysis of one of the vertebræ of the large animal cast on the Island of Stronsa, and which has been so ably described by that acute anatomist, Dr Barclay, in the first volume of the Memoirs of that Society. The analysis was made by Dr John Davy.

	Longitudinal Lamellæ.	Cellular Part.	Fibrous Part.
Animal matter, - -	45.5	52.1	60
Earth, - -	55.5	47.9	40

23. *Discovery of the Fossil Elk of Ireland in the Isle of Man.*—Some months ago, in digging a marl-pit in the Isle of Man, there was discovered a skeleton of that remarkable animal, the Fossil Elk of Ireland. The specimen, which is the most perfect and beautiful hitherto found, has been placed in the Museum of the University of Edinburgh. The metropolis of Scotland owes the possession of this splendid fossil animal to the patriotic exertions and scientific zeal of his Grace the Duke of Atholl.

24. *Facts in regard to the Bones of the Rattlesnake, by Professor Green, in a Letter to Professor Silliman.*—About the year 1748, some labourers, in working a quarry near Princetown, discovered a small cavern which contained the entire skeletons of an immense number of rattle-snakes, (Crotalus horridus). The bones were in such quantities as to require two or three carts for their removal. The cave had probably been the winter-abode of the snakes for years, where many have died through age, and others, in consequence of the mouth of the cave being shut up, either accidentally, or by the deposition of calcareous-tuff or sinter around it.

25. *Tapir of Malacca*—The Tapir hitherto considered as confined to the new world, has been met with in Malacca, and a fine specimen of the skin and skeleton of the Indian species

has been sent to the Royal Museum of Edinburgh by the Marquis of Hastings.

26. *Bojanus's Anatomy of the Testudo.*—We have much pleasure in informing our readers, particularly those who cultivate anatomy and physiology, that the second fasciculus of Bojanus's celebrated work, " Anatome Testudinis Europææ," is just published. The extraordinary accuracy of the author, his uncommon ingenuity in explaining the relations and meanings of the different parts, and the accuracy and elegance of the drawings, are so universally acknowledged, as to require no commendation from us.

27. *Helix Carychium of Gmelin.*—The shell which is here referred to, was first described by Müller, the celebrated zoologist of Denmark, in his " Vermium Terrestrium et Fluviatilium Historia," published in 1773. The characters furnished by the aperture of the shell, and by the position of the eyes and number of the tentacula of the inhabitant, induced him to institute a new genus for its reception, which he termed CARYCHIUM, employing *minimum* as its trivial appellation. Lamarck, many years after, in his " Système des Animaux sans Vertèbres," 1801, formed the genus AURICULA to include some extra European species of *Voluta*. But as this genus differs in no respect from the Carychium of Müller, its creation is to be regretted, as adding to the number of unprofitable synonimes. Cuvier, in his " Regne Animal," 1817, adopts the genus as named by his countryman, and, by inattention to habit, ranges it with his " Pulmonés aquatiques," instead of placing it after Pupa, (along with the VERTIGO of Müller, which he overlooks,) among the Pulmonés terrestres. The Carychium minimum is very common in Great Britain, inhabiting moist places among moss and dead leaves. It was first figured and described (though in an imperfect manner,) as British, in the " Testacea Minuta Rariora" of Boys and Walker, 1784, as a Turbo, (No. 51.) in which genus it has been retained by Montagu, and other British conchologists. Draparnaud figured and described two other species among the testaceous mollusca of France.—*Dr Fleming.*

28. *Instinctive attachment of the Linnet to its brood.*—The following anecdote of the common grey linnet has been

communicated to us by Mr William Strang, an enterprising farmer at Lopness, in the Island of Sanda, Orkney, and a diligent observer of facts illustrative of the natural history of the animals which frequent our northern islands. "During the summer of 1818," (says Mr Strang,) "my children having found a linnet's nest, containing four young ones nearly fledged, resolved to carry home nest and brood, with the view of feeding and taming the young birds. The parent birds, attracted by the chirping of their young, continued fluttering around the children until they reached the house. The nest was carried up stairs to the nursery, and placed outside the window. The old birds soon afterwards made their appearance; approached the nest, and fed their family, without shewing alarm. This being noticed, the nest was soon afterwards placed on a table in the middle of the apartment, and the window left open. The parent birds came boldly in, and fed their offspring as before. I was called up stairs to witness this remarkable instance of strong parental attachment. To put it still further to the test, I placed the nest and young within a bird-cage; still the old ones returned, entered boldly within the cage, and supplied the wants of their brood as before; nay, towards evening, the parent birds actually perched on the cage, regardless of the noise made around them by several children. This pleasing scene continued for several days; when an unlucky accident put an end to it, to the great grief of my young naturalists. The cage had been again set on the outside of the window, and was unluckily left exposed to one of those sudden and heavy falls of rain which often occur in the Orkneys; the consequence was, that the whole of the young were drowned in the nest. The poor parents, who had so boldly and indefatigably performed their duty, continued hovering around the house, and looking wistfully in at the window for some days, and then disappeared."

BOTANY.

29. *Remarkable Fig-Tree.*—In a preceding Number, (vol. iv. p. 204.) we gave an account of an orchard of fig-trees at Tarring, near Worthing in Sussex. We have to add, (from *Lond. Hort. Trans.* vol. iv. part 2. just published), that in the garden at Arundel Castle, the seat of the Duke of Norfolk, in the same

county, several aged fig-trees are growing as standards, and seldom fail to produce ripe fruit. They are chiefly of the kind called Violette or Bourdeaux Fig; but the largest tree is of the Marseilles variety. This remarkable standard fig-tree measures 6 feet 9 inches in circumference, at two feet from the surface of the ground: it there divides into two large arms, each of which is 3 feet and a half in circumference; and the extended branches of the tree cover a space of thirty feet in diameter.

30. *Plants of Nepaul.*—Mr David Don, keeper of the Lambertian Herbarium, is about to publish a *Prodromus Floræ Nepalensis*. In this work, many new plants will be made known, not a few of them originally discovered by our distinguished countryman Dr Francis Buchanan Hamilton.

31. *Spikenard of the Ancients.*—Among other interesting articles in the Flora Nepalensis, we understand that a full and correct botanical description of the plant which yielded the spikenard of the ancients, may be expected. This is the *Valeriana Jatamansi*. It is somewhat remarkable, that although Sir William Jones was the first who determined this point, he has, by mistake, described and figured another species of Valerian in place of the jatamansi, viz. *V. Hardwickii*, or at least he has confounded this species with the true one; for he describes the radical leaves as being cordate, while the leaves of V. jatamansi are lanceolate. In Mr Lambert's rich collection, there are specimens of the jatamansi with the fibrous roots: these agree exactly with what was formerly sold in the shops, and answer well the description given by ancient authors, as to the root resembling the tail of an ermine.

32. *Translation of Brown's Essay on the Asclepiadeæ.*—Our celebrated countryman's classical Essay "On the Asclepiadeæ," published in the 1st volume of the Wernerian Memoirs, has been translated into Latin in Germany, under the following title, "Asclepiadeæ recensitæ a Roberto Brown. Ex idiomate Anglico transtulit D. Carolus Boriwogus. Edidit Casparus, Comes Sternberg, 1819."

IV. GENERAL SCIENCE.

33. *New System of Mineralogy.*—Dr Brewster is preparing for the press a *Treatise on Mineralogy*, founded chiefly on the

physical relations of mineral bodies, and embracing an account of those remarkable phenomena which have been detected in crystallized substances by the agency of common and polarised light. In this work, the unerring characters which are derived from optical structure will be substituted in place of the ambiguous distinctions which have been generally employed; and the student will be allured to a knowledge of the science, when he finds that, in addition to the usual qualities of weight, lustre, and external form, minerals possess an internal organization which displays itself by the most beautiful optical phenomena, and exercise functions of a physical nature not less interesting than those which are exhibited in the agencies of animal and vegetable life. This Treatise will consist of two volumes 8vo., with numerous plates, and will be preceded by an Introduction, containing a popular account of the action of crystals upon polarised light; an explanation of the new method of determining primitive forms from the number of axes of double refraction; and a description of various new methods and instruments for examining and distinguishing the precious stones and other mineral substances. In his mineralogical investigations, the author has had the advantage of the freest access to the cabinets of Mr Thomas Allan and Sir George Mackenzie, and has been supplied in the most liberal manner with individual minerals from the cabinets of Mr Ferguson of Raith, Mr Heuland and Mr Brooke. He will still, however, receive with gratitude, and carefully return, any curious specimens of rare minerals which may be entrusted to him for examination.

34. *Method of playing on the Violin and Violincello at the same time.*—In Vol. iii. p. 194. of this Journal, we mentioned the ingenious contrivance for this purpose, by Mr James Watson, a blind musician from Dundee. Since that time he has not only improved but extended the mechanism, and we had the pleasure of seeing it exhibited before the Directors of the Asylum for the Blind, to the satisfaction of all who were present. The following account of the improved mechanism is taken from No. 3. of the Caledonian Quarterly Journal: "The stops by which he shortens the strings of his violincello have been fitted with more elegance and precision, additional springs have been added, to assist and relieve his leg in the ope-

ration of bowing; and the bow has been fastened to his foot by new machinery, which insures more powerful and steady execution. Indeed, the whole of this machinery is now so constructed, that he can play both instruments for a very great length of time, without more fatigue than if he played only upon one. Nor is this all: for, by the very nice and accurate application of mechanism, wholly invented by himself, he can perform upon two violincellos at the same time; and the one upon which he plays the principal strain, is so contrived as to have the power and tone of two played by different performers; so that he may be said to play three violincellos,—the principal strain upon two, and the bass upon a third. Nor is this compass limited; for the instrument upon which he plays the principal has a range of sixty-four semi-tones, and more could be added if necessary." We understand that there is to be a public promenade for the benefit of Mr Watson, and we trust that the ingenuity of this very respectable individual will be well rewarded.

35. *Notice regarding the Expedition to explore the Sources of the Missisippi.*—A letter from the Corresponding Secretary of the Lyceum at New York to R. K. Greville, Esq. mentions, that the party, which consisted of forty persons, had just returned, without having experienced a single accident, after having travelled in different directions about 6000 miles. They first proceeded to the Lakes Huron and Superior, through which they passed, and from the bottom of the last-mentioned lake ascended a river to its source, which, with a small portage of a very few miles, brought them to the main branch of the Missisippi. This branch they ascended 300 miles to its source. They then (being 2100 miles above St Louis) descended 900 miles to the Ouisoncin, a river emptying itself into the Missisippi from the east. This they also ascended to its source. From thence a small portage of four miles brought them to the head of a river emptying itself into Lake Michigan, the whole coast of which they carefully examined. They have corrected many gross errors in the topography of these hitherto almost unknown regions, and promise to add much to the zoology and geology of that country. The Falls of St Anthony, the height of which has been so much exaggerated, they have reduced to 70 feet, (the

region chiefly limestone). Amongst various objects of natural history, is what the travellers termed a *sand-tree:* it was about two feet high, and resembled a tree with its branches. It was found on the shore of Lake Michigan, and on examination proved to be a parasitic fungus, completely encrusted with sand, which in that region drives as on the Arabian Desert. It is in contemplation to send another expedition for the same purposes, and to the same regions, next year.

36. *Prevention of Rust.*—The prevention of rust, on such articles of furniture as are made of polished steel, is an object of great importance in domestic economy. The cutlers in Sheffield, when they have given knife or razor blades the requisite degree of polish, rub them with powdered quicklime, in order to prevent them from tarnishing; and we have been informed, that articles made of polished steel, are dipt in lime-water by the manufacturer, before they are sent into the retail market.

37. *Latitude and Longitude of Places in New South Britain.*—Principal Baird has communicated to us the following valuable Table:

Start Point, - -	62° 42′ S.	61° 28′ W
Cape Sherriff, - -	62 26	60 54
Desolation Island, - -	62 27	60 35
Smith's Island,		
Cape Melville, - -	62 1	57 44
Martin's Head, - -	62 12	58 20
Penguin Island, south end, -	62 6	58 6
Bridgeman's Island,		
Tower Island, - - -	63 30	60 30
Hope Island, - - -	63 5	57 4
Cape Bowles, - - -	61 19	54 10
O'Brien's Island,		
Seal Island, and Reef, -	61 1	55 33
Cape Valentine, - -	61 3	54 48
Cornwallis Island, - -	61 0	54 36
Lloyd's Promontory, Clarence's Island, north end,	61 2	54 10
Ridley's Island, north end, -	61 5	58 23
Falcon Island, - - -	62 18	59 56

38. *Method of consuming Smoke.*—The following method of consuming smoke, has been communicated to us by John Robison, Esq. F. R. S. E. " An accidental observation of an explosion in a laundry-stove, having suggested to me a probable

method of consuming the smoke of the engines of steam-boats, I beg leave to propose it as a subject of experiment. In the case of the stove, (which a short time before had the whole surface of the ignited coal covered with slack), I observed that a sudden accession of air at the inner end of the fire-place, *i. e.* the end nearest the chimney, caused a considerable explosion, and burst of flame, which reached far up the chimney. This must have arisen from the inflammation of the coal-gas which had been previously passing quietly up the pipe. The fire in steam-boat boilers is very similarly situated to that in this stove, and it appears to me, that if one or more cast-iron pipes were passed through the sides of the boiler, so as to make a stream of air play on the back end of the fire, the inflammable gas generated when fresh fuel is thrown in would be inflamed as fast as produced, and the smoke and tar would be in a great measure consumed, thus affording additional heat, and removing a nuisance. The iron-tubes might at the same time serve as stays for supporting the sides of the boilers.

39. *School of Arts.*—A School of Arts has been established in Edinburgh, for the instruction of mechanics in such branches of science as are of practical application in their several trades. Lectures on Practical Mechanics and Practical Chemistry will be delivered twice a week during the winter season. A library, containing books on popular and practical Science, has already been established.

The Institution will be conducted under the direction of the following Committee:

David Brewster LL. D. F. R. S. L., and Sec. R. S. E.
Professor Pillans, F. R. S. E.
James Skene. Esq. of Rubislaw, F. R. S. E.
John Murray, Esq. Advocate.
George Forbes, Esq. F. R. S E., *Treasurer.*
Leonard Horner, F. R. S. of L. & E., *Secretary.*
James Jardine, Esq. F. R. S. E. Civil Engineer.
William Playfair, Esq. Architect.
The Deacon of the Incorporation of Hammermen.
The Deacon of the Incorporation of Goldsmiths.
The Deacons of the Incorporation of Mary's Chapel.
Mr James Milne, Brass-Founder.
Mr Robert Bryson, Watchmaker.
Mr John Ruthven, Engineer and Printer.

Mr James Cochrane, *Clerk & Librarian.*

Donations in Books and Models will be gratefully received by the Committee.

Art. XXXIII.—*List of Patents granted in Scotland since 23d January* 1821.

3. To Robert Bowman of Manchester, manufacturer, for "Improvements in the construction of looms for weaving various sorts of cloths; which looms may be set in motion by any adequate power." Sealed at Edinburgh 27th March 1821.

4. To Samuel Kenrick of West Broomwich, county of Stafford, manufacturer, for an "Improved method of tinning cast-iron vessels of capacity." Sealed at Edinburgh 27th March 1821.

5. To Henry Brown of Derby, chemist, for an "Improvement in the construction of boilers, whereby a considerable saving of fuel is effected, and smoke rapidly consumed." Sealed at Edinburgh, 27th March 1821.

6. To Phillip London the younger, of Cannon Street, London, practical chemist, for "A certain improvement in the application of heat to coppers, and other utensils." Sealed at Edinburgh 27th March 1821.

7. To Ilario Pellafenet of Earl's Court, Middlesex, gentleman, for "Certain new and improved machinery, and methods for breaking, bleaching, preparing, manufacturing, and spinning in thread or yarn, flax, hemp, and other productions, and substances of the like nature, capable of being manufactured into thread or yarn." Sealed at Edinburgh 2d April 1821.

8. To Thomas Masterman of 38. Broad Street, Ratcliffe, Middlesex, brewer, for "Certain machinery for the purpose of imparting motion, to be worked by steam and water, or other fluid, without either cylinder, piston, or fly-wheel, and with less loss of power than occurs in working any of the steam-engines now in general use." Sealed at Edinburgh 13th April 1821.

9. To Robert Salmon of Woburn, county of Bedford, Esq. for "Certain improvements in the construction of instruments for the relief of hernia and prolapsis; which instruments, so improved, he denominates Scientific-principled, variable, se-

cure, light, easy, elegant, cheap, and durable, trusses." Sealed at Edinburgh 18th April 1821.

10. To James White of Manchester, civil engineer, for "Certain new machinery adapted to preparing and spinning wool, cotton, and other fibrous substances, and uniting several threads into one, and also certain combinations of the said new machinery with other machines, or with various parts only of other machines already known and in use. Sealed at Edinburgh 18th April 1821.

11. To Charles Phillips, of the city and county of Haverford-west, Commander in the Navy, for certain "Improvements upon capstans." Sealed at Edinburgh 28th May 1821.

12. To Richard Jones Tomlinson of Bristol, merchant, for "An improved rafter for roofs, or beam for other purposes." Sealed at Edinburgh 25th May 1821.

13. To Robert Delap of Belfast, Ireland, for "Certain improvements in producing rotatory motion." Sealed at Edinburgh 25th May 1821.

14. To Samuel Hall of Rasford, county of Nottingham, cotton-spinner, for "An improvement in the manufacture of starch." Sealed at Edinburgh 25th May 1821.

15. To William Frederick Colland of 195. Tottenham Court Road, parish of St Pancras, county of Middlesex, musical instrument-maker, for "Certain improvements on musical instruments called Piano-fortes." Sealed at Edinburgh 30th May 1821.

16. To John Leigh Bradbury of Manchester, gentleman, for "A new mode of engraving and etching metal rollers used for printing upon woollen, cotton, linen, paper, cloth, silk, and other substances. Sealed at Edinburgh 1st June 1821.

P. Neill, Printer.

THE

EDINBURGH

PHILOSOPHICAL JOURNAL.

ART. I.—*Description of Bridges of Suspension.* By ROBERT STEVENSON, Esq. F. R. S. E. Civil Engineer. Communicated by the Author.

THE art of building bridges, or at least of forming some equivalent for a bridge, must have been coeval with the earliest stages of civilization. At this day, the common mode of crossing rivers and ravines in the wilds of America, and the inland territory of Hindostan, is by means of ropes of various kinds, stretched from side to side, on which a roadway is generally formed for the traveller and his equipage; though, in some instances, he is placed in a basket, with his goods suspended from the ropes, and drawn across, while his mule fords the stream, or clambers through the ravine.

It may even be considered as rather a mortifying circumstance, that, in the present advanced state of the arts, we should be laying aside the stupendous arch of masonry, with all its strength and symmetry, and adopting bridges of suspension, formed of flexible chains, in imitation of the more rude and simple efforts of early times. We wish not, however, to be understood to underrate modern science, but would rather acknowledge our obligations to the mechanical philosopher, who has thus converted the catenarian curve to a useful purpose, by turning the crude ideas of savage life to advantage, even in the most advanced state of society. When, from more extended views, or from motives of economy, a check is put to our application of the bridge of masonry, in certain situations, it is highly gratifying to observe, that, by this contrivance, we are enabled to ac-

complish the transit of goods and passengers over a river, or even an arm of the sea, in a manner which, but a few years since, would have been considered as wholly impracticable.

Bridges of Cast-iron.—During the late war, when the prices of timber and iron, of foreign production, had become extravagantly high, every means was resorted to for the introduction of iron of British manufacture into works of almost every description. Among these, its application to bridges of cast-iron soon became conspicuous. The first bridge of this metal appears to have been erected in the year 1779, over the Severn, near the iron-works of Colebrook Dale in Shropshire. It consisted of one massive arch of 100 feet. Soon after this bold attempt, a number of cast-iron bridges were erected in various parts of the United Kingdom; the most considerable of which, was that upon the river Wear at Sunderland, which measures 236 feet in the span; and more lately, we have the bridge of Southwark over the Thames, the design of Mr Rennie, the middle arch of which is no less than 240 feet in the span. Propositions have even been made for extending arches of cast-iron to upwards of 500 feet. These stupendous works in cast-iron, which are unquestionably the invention of British artists, have their limits, however, both in regard to extent, and also as works of a very expensive nature. Other means were therefore still wanting, to enable the engineer, in many situations, to substitute a continuous roadway for a dangerous and troublesome ferry. This has been effected with wonderful simplicity and economy, by the application of the catenarian curve, the properties of which have hitherto been regarded, by mathematicians, only as a matter of curious enquiry; but now, by the use of malleable iron-chains, in the form of an inverted arch, this curve is applicable to bridges of suspension, substituted for arches of the usual form.

Winch Chain-bridge.—The earliest bridges of suspension of which we have any account, are those of China, said to be of great extent; Major Rennell also describes a bridge of this kind over the Sampoo in Hindostan, of about 600 feet in length. But the first chain-bridge in our own country, is believed to have been that of Winch Bridge over the river Tees, forming a communication between the counties of Durham and York. This

bridge is noticed, and an elevation of it given, in the *third* volume of Hutchinson's Antiquities of Durham, printed at Carlisle in 1794. As this volume is extremely scarce, owing to the greater part of the impression having been accidentally destroyed by fire, the writer of this article applied for a sight of it from the library of his friend, Mr Isaac Cookson of Newcastle-upon-Tyne, with whose permission a sketch of this original British chain-bridge is given in Plate VIII. Fig. 1. The following account is given by Hutchinson at p. 279. "The environs of the river (Tees) abound with the most picturesque and romantic scenes; beautiful falls of water, rocks and grotesque caverns. About two miles above Middleton, where the river falls in repeated cascades, a bridge suspended on iron-chains, is stretched from rock to rock, over a chasm near 60 feet deep, for the passage of travellers, but particularly of miners; the bridge is 70 feet in length, and little more than 2 feet broad, with a handrail on one side, and planked in such a manner, that the traveller experiences all the tremulous motion of the chain, and sees himself suspended over a roaring gulph, on an agitated and restless gangway, to which few strangers dare trust themselves." We regret that we have not been able to learn the precise date of the erection of this bridge, but, from good authority, we have ascertained that it was erected about the year 1741.

American Bridges of Suspension.—It appears from a treatise on bridges by Mr Thomas Pope, architect, of New-York, published in that city in the year 1811, that eight chain-bridges have been erected upon the catenarian principle, in different parts of America. It here deserves our particular notice, however, in any claim for priority of invention with our Transatlantic friends, that the chain-bridge over the Tees was known in America, as Pope quotes Hutchinson's Vol. III., and gives a description of Winch Bridge. It further appears from this work, that a patent was granted by the American Government, for the erection of bridges of suspension, in the year 1808. Our American author also describes a bridge of this construction, which seems to have been erected about the year 1809, over the river Merrimack, in the State of Massachusets, consisting of a catenarian arch of 244 feet span. The road-

way of this bridge is suspended between two abutments or towers of masonry, 37 feet in height, on which piers of carpentry are erected, which are 35 feet in height. Over these ten chains are suspended, each measuring 516 feet in length, their ends being sunk into deep pits on both sides of the river, where they are secured by large stones. The bridge over the Merimack has two carriage ways, each of fifteen feet in breadth. It is also described as having three chains, which range along the sides, and four in the middle, or between the two roadways. The whole expence of this American work is estimated to have been 20,000 dollars, and the bridge calculated to support or carry about 500 tons.

Proposed Bridge at Runcorn.—Perhaps the most precarious and difficult problem ever presented to the consideration of the British engineer, was the suggestion of some highly patriotic gentlemen of Liverpool, for constructing a bridge over the estuary of the Mersey at Runcorn Gap, about 20 miles from Liverpool. The specifications for this work provided, that the span of the bridge should measure at least 1000 feet, and that its height above the surface of the water should not be less than 60 feet, so as to admit of the free navigation of this great commercial river. The idea of a bridge at Runcorn, we believe, was first conceived about the year 1813, when the demand for labour was extremely low, and a vast number of the working classes of Lancashire were thrown out of employment. A variety of designs for this bridge were procured by a select committee of the gentlemen who took an interest in this great undertaking. The plan most approved of, however, was the design of a bridge of suspension; and Mr Telford the engineer, and Captain Brown of the Royal Navy, are understood pretty nearly to have concurred in opinion as to the practicability of such a work. Mr Telford has reported fully on the subject, and has estimated the expence of his design at from L. 63,000 to L. 85,000 according to different modes of execution. Though as yet little advancement has been made in carrying this enterprising design into execution, yet the novelty and magnitude of an arch of 1000 feet span, is a subject of so much interest, that we have thought it proper in this place to mention these circumstances.

Menai Chain-Bridge.—The Straits of Menai, which separate the island of Anglesea from Caernarvonshire, have long formed a troublesome obstruction upon the great road from London to Dublin by Holyhead, by which the troublesome ferry of Bangor might be avoided. Many plans for the execution of this undertaking have also been agitated, chiefly in cast-iron, including a range of estimate from about L. 128,000 to L. 268,000; but that which is now acted upon, is a bridge of suspension upon the catenarian principle, the extent of which, between the piers or points of suspension, is to be 560 feet, the estimate for which is only about L. 70,000. This, by many, has been considered a work of great uncertainty; but the Union Bridge on this plan has already been executed on the Tweed, to the extent of 361 feet, as we shall afterwards more particularly notice. We shall now proceed to give some general account of the progress of malleable-iron bridges in Scotland, where this art, at least to any considerable extent, has been first put in practice in Great Britain.

Galashiels Wire-Bridge.—We have already alluded to the great designs of chain-bridges for the river Mersey and the Straits of Menai. The first practical example, however, of this kind, was that over Tees, Pl. VIII. Fig. 1. The next malleable iron-bridges, which we know of in this country, were those executed on the river Tweed, and its tributary streams of Gala and Etterick. Mr Richard Lees, an extensive woollen-cloth manufacturer at Galashiels, whose works are situate on both sides of Gala-Water, conceived the idea of forming a foot-bridge, of slender iron-wires, for the conveniency of communicating readily with the different partsof his works. This gangway, or bridge, was erected in the month of November 1816; its extent is 111 feet, and it cost about L. 40. Though only of a very temporary, and even imperfect construction, yet being the first wire-bridge erected in Great Britain, it deserves our particular notice, as affording a useful practical example of the tenacity of iron so applied, and of its utility in many situations, and particularly in an inland country such as the vale of the Tweed, where the carriage of bulky materials, of every description, is extremely expensive.

Kings-meadows Wire-Bridge.—The wire-bridge followed

the chain-bridge of Dryburgh; but we shall first describe the wire-bridge of Kingsmeadows, on the estate of Sir John Hay, Bart., of which we have given a sketch in Fig. 2. This foot-bridge is thrown across the Tweed, a little below Peebles. It is 110 feet in length, and 4 feet in breadth, and is ornamented with a handsome lodge or cottage, as will be seen delineated on the sketch. This work was contracted for, and executed by Messrs Redpath and Brown, of Edinburgh, in the summer of 1817, and cost about L. 160.

It may be described as consisting of two hollow tubes of cast-iron, which are erected on the opposite sides of the river, set 4 feet apart, into each of which a corresponding bar of malleable iron is fitted, and to these the suspending wires and braces are respectively attached by screw bolts. The lower ends of the hollow tubes forming the piers, are secured by a brander or grating of timber, (according to a plan by Mr Turnbull, architect in Peebles), laid under ground, and shewn in the connecting diagram, marked letter *a*. Fig. 2. They are further supported under the roadway, by struts or diagonal posts, which act against the strain of the weight and motion of the suspended roadway. The upright bars noticed above, form the gates or approaches to the bridge; and to these the suspending wires and braces are attached; their respective lengths being adjusted at pleasure, by screw-bolts. These hollow tubes of cast-iron measure 9 feet in height, 8 inches in diameter, and $\frac{3}{4}$ths of an inch in thickness of metal. The malleable iron-bars, which are inserted into these hollow tubes, form the points of suspension, measure 10 feet in height, and are $2\frac{1}{2}$ inches square.

The roadway is formed with frames of malleable iron, to which deal boards, measuring 6 inches in breadth, and $1\frac{1}{2}$ inch in thickness, are fixed with screw-bolts. The side-rails are neatly framed with rod-iron, on which a coping, or hand-rail of timber, is fixed. The roadway here is suspended by diagonal wires, in a manner different from the catenarian principle, as will be seen by comparing Fig. 2. with Figs. 1. 3. and 4. Plate VIII. The chain-suspending wires of Fig. 2. are of the strength known to artists as No. I. of the wire-gauge, measuring about $\frac{3}{16}$ths of an inch in diameter. The back or land-ward braces are made of bolt-iron, $\frac{3}{4}$ths of an inch in diameter,

formed into links of from five to six feet in length. The screw-bolts are 1 inch in diameter, and are in all 42 in number, by which the whole of the suspending rods and wires may be tightened, and set up at pleasure. When thus braced, the roadway of the bridge is found to have little or no vibration, having only such a tremor as rather tends to convey the idea of firmness and security. As a proof of the strength of this bridge, when newly finished, it was completely crowded with people, without sustaining any injury.

Thirlstane Wire-Bridge.—The only other wire-bridge which we shall notice, is that erected by the Hon. Captain Napier, over the Etterick, at Thirlstane Castle. A foot-bridge of ropework had originally been thrown across here; but a wire-bridge is now erected, and measures about 125 feet span.

Dryburgh Chain-Bridge.—The wire-bridges of Galashiels, Kingsmeadows, and Thirlstane, above described, are suspended by diagonal braces, as shewn in Fig. 2. The same plan was also followed in the first erected bridge at Dryburgh Abbey, where the suspending rods were also made to radiate from their points of suspension on either side, towards the centre of the roadway, for as yet the catenarian principle had not been introduced upon the Tweed. The bridge at Dryburgh is 260 feet in extent between the points of suspension, and is 4 feet in breadth. It was executed by Messrs John and William Smith, builders and architects near Melrose, at the expence of the Earl of Buchan, as proprietor of the ferry, and has altogether cost his Lordship about L. 720. This bridge is constructed for foot passengers and *led horses.* It was originally begun on the 13th of April 1817, and was opened to the public on the 1st day of August following, having required little more than four months for its erection.

It is observed by Mr John Smith, one of the gentlemen above alluded to, that when the original bridge of Dryburgh was finished, upon the diagonal principle like Fig. 2., it had a gentle vibratory motion, which was sensibly felt in passing along it; the most material defect in its construction arising from the loose state of the radiating or diagonal chains, which, in proportion to their lengths, formed segments of catenarian curves of different radii. The motions of these chains were found so subject to ac-

celeration, that three or four persons, who were very improperly amusing themselves, by trying the extent of this motion, produced such an agitation in all its parts, that one of the longest of the radiating chains broke near the point of its suspension. On another occasion, in a very high wind, one of the horizontal chains, stretched under the beams of the roadway, gave way. But, on the 15th of January 1818, after this bridge had been finished about six months, a most violent gale of wind took place, when the vibrating motion of the bridge was so great, that the longest radiating chains were again broken, the platform blown down, and the bridge completely destroyed. Messrs Smith happened unluckily to be from home at the time of the accident, but on examining a number of persons who saw it, they all concurred in stating, that the vertical motion of the roadway of the bridge before its fall, was as nearly as may be equal to its lateral motion, and was altogether concluded to be such as would have pitched or thrown a person walking along it into the river.

The eyes, formed on one end of the rods or links of the chains of this bridge, were welded, but the other end was simply turned round, and fixed with a collar, as shewn in the connecting diagrams, marked *b*, Fig. 3. It further deserves particular notice, that after the bridge fell, and on a careful examination of the rods or links, not more than one or two instances appeared of the iron having failed at the welded end, but had uniformly broken at the open eye of the link, as shewn in the diagrams *b*, *b*, above alluded to,—a mode of construction which had been recommended to Messrs Smith, by an experienced blacksmith.

The sudden destruction of this bridge, created a great sensation of regret throughout all parts of the country, and was considered an occurrence of so much importance in the erection of chain-bridges, that several of the gentlemen of Liverpool, interested in the proposed bridge at Runcorn, made a journey to Scotland, for the express purpose of inquiring into the circumstances of the misfortune. Messrs Smith, the contractors, had engaged with the Earl of Buchan, to erect this chain-bridge for somewhat less than L. 500, and were bound to uphold it against all accidents only during the period of its erection, so that the loss fell wholly upon Lord Buchan.

The utility of Dryburgh Bridge, when compared with a troublesome ferry, even on the short experience of six months, had given it such a decided preference to the boat, that his Lordship, without hesitation, directed that it should be immediately restored: this was accordingly done, after a better design, for the additional sum of about L. 220, and in less than three months it was again opened to the public. This bridge is now constructed upon the catenarian principle, agreeably to Fig. 3., the roadway being suspended by perpendicular rods of iron, from main or catenarian chains. The chief mechanical alterations upon the former plan consist in welding both eyes or ends of the links, instead of having one of them simply turned round, and fixed with a collar; the roadway has also been strengthened by a strongly trussed wooden rail, which also answers the purpose of a parapet, on each side of the bridge, the good effects of which were particularly exemplified, while the bridge was building. A high wind having occurred before the side-rails were erected, one end of the platform was lifted above the level of the roadway, and the undulating motion produced on this occasion is described as resembling a wave of the sea; an effect which pervaded the whole extent of the bridge, and went off with a jerking motion at the farther end. But after the side-rails were attached, this vertical motion was checked, and is now found to be greatly reduced. There were also added to the newly constructed bridge at Dryburgh, guys or mooring-chains, consisting of rods of iron fixed to stakes in the opposite banks of the river. These guys are attached to the beams of the roadway, as shewn on the plan connected with Fig. 3. These diagonal moorings are said to have some effect in lessening the motion of the bridge in high winds, but it did not appear to the writer of this article, when he examined the bridge in 1820, that these guys could act in any very sensible degree in this respect.

We have already stated generally, that the new bridge at Dryburgh is erected upon the catenarian principle. It may further be described as consisting of four main chains, which are suspended in pairs between the points of suspension, in a horizontal position relatively to each other; the lowest part of

the curve of each pair of chains coming under the top of their corresponding side-rails, as shewn in Fig. 3. The links of the catenarian chains are formed of rods of bar-iron, measuring $1\frac{3}{8}$th inches in diameter, constructed in lengths of about 10 feet each. The eyes at each end of these long rods are connected by short links of an oval form, measuring about 9 inches in length. The platform or roadway is suspended from the catenarian chains, by perpendicular rods of iron, of the strength of $\frac{1}{2}$ inch in diameter, which are attached at their upper ends to the short links above described, by a kind of cross head, while the under ends of these perpendicular rods, forming a screw-bolt, pass through the side-beams of the platform, and are attached to them with screw-nuts, resting upon corresponding *washers*, or plates of iron.

The points of suspension of this bridge rest upon upright posts, and are elevated 28 feet above the level of the roadway, on each side of the river. The catenarian chains pass over these upright posts or piers, which are formed of logs of Memel timber, 14 inches square, erected in pairs, as shewn in the left hand diagram of Fig. 3., marked "Approach of Fig. 3." These pieces of framed work leave a space of 9 feet in width, as an approach to the roadway of the bridge. The tops are connected by the *transom-beam*, on which the catenarian chains rest, and from thence they descend in curved lines, as shewn in the figure. Each pair of chains are 12 feet apart at the approaches of the bridge, but they are made to converge towards its centre, where they are attached to the side-rails, and measure only $4\frac{1}{2}$ feet apart, being the breadth of the roadway between the side-rails. By this converging form, the chains answer in some measure the purpose of guys to the roadway. It is, however, questionable, how far it is proper to give an oblique direction to the main chains; indeed we are rather inclined to think, that the main chains of bridges of suspension should be kept parallel to the direction of the strain.

The platform or roadway of Dryburgh Bridge is elevated about 18 feet above the surface of the river, when in its state of summer water. It consists of two beams of fir-timber, which run along the extent of the bridge, and are connected to each

other with rails, or pieces of timber mortised into them. The side-rails answering the purposes of hand-rails, are formed with diagonal braces and cross ties. The roadway is finished with a cleading of boards laid across the direction of the roadway, leaving openings of about $\frac{3}{4}$ths of an inch between each of the boards, to let off the moisture in wet weather. Under the platform, two chains made of circular rods, 1 inch in diameter, are stretched beneath the beams, and connected with the abutments of masonry on each side, as an additional security.

The back braces or landward chains employed for keeping the upright posts erect, and for counteracting the weight of the bridge, are made of rod-iron, 1 inch in diameter, which are sunk a considerable way into the ground, and pass through large flat stones, which are loaded with a mass of masonry, built in an arched form, and acting as ballast, as shewn in Fig. 3.

An occurrence took place, during the erection of Dryburgh Bridge, which deserves to be particularly noticed. It was observed, that the catenarian curve was not the same when the main chains were simply suspended with their own weight, as when they came to be loaded with the roadway. At the extremity of the chains on each side, and in the centre of the bridge, the points of attachment remained stationary after the catenarian chains were loaded, but between the centre and either abutment, the roadway made two distinct curves, the versed sine of which measured about 7 inches. This defect was easily rectified, by shortening the suspending chains; but it serves to shew the liability of the catenarian curve to alter, when loaded in the direction of the horizontal plane of the connecting roadway.

For the erection of a bridge at Dryburgh, on a ferry of comparatively small importance, the public are under no small obligations to the Earl of Buchan: and the enterprise which marks the design and execution of it, confers honour on the architects.

Union Chain-Bridge.—The work to which we next refer the reader, is the Union Bridge across the river Tweed at Norham Ford, about five miles from Berwick, of which we have given a sketch in Fig. 4. The work here was begun in the month of August 1819, and the bridge was opened on the 26th July 1820, having required only a period of about twelve

months for its erection; while a stone-bridge must have been the work of about three years. This work was designed and executed by Captain Samuel Brown, of the Royal Navy, who has so successfully introduced the use of the chain-cable into the Navy and Mercantile marine.

The roadway of this bold design is made of timber, on which iron cart-tracks are laid for the carriage wheels. It is 18 feet in width, and is no less than 361 feet in length. The main beams or joisting measures 15 inches in depth, and 7 inches in thickness. The timber cleading or planks are 12 inches in breadth, and 3 inches in thickness. This great platform is suspended at the height of 27 feet above the surface of the summer water of the river. It is also made to rise about 2 feet in the centre, and is finished on each side with a cornice of 15 inches in depth, which adds to its ornament, and gives it an additional appearance of strength.

The roadway is suspended from the catenarian or main chains by circular rods of iron, which measure 1 inch in diameter. These perpendicular rods are wedged into caps or pieces of cast-iron, called Saddles, which are placed at the distance of 5 feet apart, and are made to rest upon the shackles or joints of the catenarian chains, as shewn in the connecting diagram, marked *c*. Fig. 4. The attachment of the lower ends of these rods to the beams of the platform which they pass through, is by their embracing a bar of iron which runs along the whole extent of the bridge under the beams of the roadway, on each side. These bars measure 3 inches in depth, and they are connected with the suspending rods by a spear or bolt, which, in a very simple manner, completes the connection of the roadway with the perpendicular suspending rods, and catenarian chains.

The catenarian chains of this bridge are twelve in number, ranged in pairs; the one pair being placed over the other, between the points of suspension on each side of the bridge. These chains, and indeed the whole of the iron-work, is made of the very best Welch iron. The chains are worked into a circular form, and measure about 2 inches in diameter. The Links, as they may be termed, consist of rods of 15 feet in length, and have bolt-holes, which are strongly welded, and neatly finished at each end. These links or rods are connected together by

strong shackles, as shewn in the connecting diagram, Fig. 4.; and a bolt is passed through them, which is of an oval form, measuring $2\frac{1}{4}$ by $2\frac{1}{2}$ inches. At each joint of the three tiers of the catenarian chains respectively, one of the saddle pieces of cast-iron, formerly alluded to, are introduced. The first saddle piece, with its suspending rod, for example, on either side of the bridge, may be conceived as resting on the upper pair of chains, as will be observed in the elevation of Fig. 4.; the next saddle-piece in the longitudinal direction of the roadway, rests upon the middle pair of chains, and the third upon the lower pair, and so on alternately, throughout the whole extent of the bridge. By this means all the chains bear an equal strain, and the joints are arranged in so precise and orderly a manner, that a saddle-piece and perpendicular suspending-rod occurs at every 5 feet, so that the distance between each pair of suspending-rods forms a space of 5 feet. By this beautiful and simple arrangement, the suspending-rods are made to rest upon the joints of the catenarian chains, so that the links or rods of which they are composed, are kept free of distortion, when loaded with the weight of the suspended roadway.

The spaces of 5 feet between the suspending rods above alluded to, are formed into meshes of 6 inches square, to the height of 5 feet on each side of the bridge, and answer the purposes of a parapet wall for the safety of passengers.

Though the timber roadway is only about 361 feet in length, yet the chord-line of the main-chains measures no less than 432 feet between the points of suspension, with which they make an angle of about 12°, and in forming the catenarian curve-drop, at the rate of 1 perpendicular to about 7 feet in the length of chain, the versed sine of the middle pair of chains being about 26 feet. The twelve main chains, with their apparatus, weigh about 5 tons each, and the weight of the whole bridge, between the points of suspension, has been estimated at 100 tons.

On the Scotch side of the river, the catenarian chains pass over a pillar of aisler masonry, which measures 60 feet in height, is about 36 feet in its medium width, and $17\frac{1}{2}$ feet in thickness. The sides of the lower 10 feet of the walls of this pillar are square, but at this height the walls begin to slope at the rate of 1 perpendicular to 12 horizontal. The archway in the masonry of this pillar,

which forms the immediate approach to the roadway, measures 12 feet in width, and 17 feet in height. Each pair of main chains being suspended horizontally, pass through corresponding apertures in the masonry, at the distance of about 2 feet above one another, and go over rollers connected with the building. The links of the main chains at these points are made as short as the strength or thickness of the iron will permit of their being welded, in order that they may pass over the rollers, without distorting or unduly straining the iron. After going through the masonry of the pillar, the chains are continued in a sloping direction to the ground, as shewn in Fig. 4. Here they are sunk to the depth of 24 feet, where they pass through great *ballast plates* of cast-iron, into which they are stopped by a strong iron spear or bolt, of an oval form, measuring 3 inches by 3½ inches in thickness. The cast-iron ballast plates measure 6 feet in length, 5 feet in breadth, and 5 inches in thickness in the central parts; but towards the edge, they diminish in thickness to 2½ inches. The ends of the chains thus fixed, are loaded with *mound-stones* and earthy matters, to the level of the roadway of the bridge.

On the English side of the Tweed, the pillar or tower of masonry forming the abutment or point of suspension, is built upon a bench or foundation, excavated in the face of a precipitous sandstone rock, and is only about 20 feet in height, but its other dimensions correspond with the upper part of the masonry on the Scotch side. The chains on the English side are made to rest upon plates of cast-iron, included in the masonry, instead of rollers, as on the opposite side. Here the ballast-plates are of the same dimensions as those already described, but instead of being sunk into the ground, as on the Scotch side, their position is rather above the foundation of the pillar, where they are set nearly perpendicular, but are placed so as to correspond with the direction of the strain or weight of the bridge. For the greater security of the position of these ballast-plates on the English side, they are connected with a horizontal arch of masonry, which is *dovetailed* into the rock. This part of the work, however, was not in a finished state when the writer of this article saw it, at the ceremony of opening the bridge on the 26th of July 1820. Upon this side, the approach to the roadway forms a curve in

front of the pillar, instead of passing through an archway, as on the Scotch side, as will be observed by inspecting the elevation and diagrams of Fig. 4.

The general effect of the Union Bridge, which we have now endeavoured to describe, is interesting and curious; and such is the extent, and its light and elegant appearance, that it has not inaptly been compared to an inverted rainbow. Those who visit this undertaking, as affording much novelty to the scenery of this part of the banks of the Tweed, will not be disappointed in their expectations; while, in a national point of view, as a great improvement, it deserves the most particular consideration of the country at large. It is also of much interest to the professional Engineer, especially as being the first bridge of suspension erected in Great Britain, calculated for the passage of loaded carriages. Nor ought the enterprising efforts of Mr Molle, and the gentlemen of the adjoining shires of Berwick and Northumberland, to be overlooked in the prosecuting of this design, as affording a great practical lesson for the application of bridges of this construction to various parts of the United Kingdom, where stone or even cast-iron would be found impracticable, both on account of the extent of the situation, and the unavoidable expence of the works.

The fastidious, upon examining this work, may perhaps find some parts of the general design capable of improvement, and when a second work of a similar or a greater extent comes to be executed, there is little doubt that experience will, in the usual course of things, lead to alterations for the better. We, however think, that the design and execution of the Union Bridge, does the highest credit to Captain Brown, in the construction of bridges on the catenarian principle. We understand that the whole works of the Union Bridge, for masonry, carpentry and smithery, were undertaken by the Captain, for the sum of about L. 5000, whilst the execution of a bridge of stone must have cost at least four times that sum. The object of its projector, however, does not appear to have been the realization even of the cost of this bridge:—it was undertaken chiefly with a view to shew the application of chain-cables to his favourite object of bridge-building, and it is hoped that his well merited exertions will ultimately meet with a proper remu-

neration in the execution of many works of a similar nature. The trustees for this bridge, with proper liberality, have presented Captain Brown with 1000 guineas since the completion of the work, over and above his estimated price.

Design for Cramond Bridge.—Fig. 5., in Plate VIII., is descriptive of a plan which was originally intended for crossing the river Almond, on the great north road between Edinburgh and Queensferry. The extent of the span between the points of suspension here, is laid down at 150 feet. The chief circumstances which particularize this design, are a mode of fixing the catenarian chains to the abutments of suspension on each side of the river, and in dispensing with that part of the piers which rises above the road-way, by which the main chains are unavoidably prevented from being distributed equally under the road-way. The main chains are likewise made to collapse or turn round the abutments of masonry, as will be seen from the section in which the parts of the work are so contrived, that access can be had to the chains, by an arched way on each side, marked *d* on Fig. 5. In this design, the two ends of the catenarian chains are formed into great *nails* or bolts, with countersunk or conical heads made to fit into corresponding hollow tubes of cast-iron, included *in* the masonry of the abutments.

From this description, the reader will readily form an idea of the simplicity and effect of this mode of fixing the chains, being such, also, that any particular chain may be withdrawn and replaced, without deranging the fabric of the bridge. The roadway, instead of being suspended from the main chains, is made up to the proper level upon the catenarian chains, by a frame work of cast-iron, prepared for the reception of a stratum of broken stones for the road.

The making up of the roadway of this bridge, however, and the enlarged angle of its suspension, may be considered as limiting the span or extent of bridges of this construction, to about 200 feet. The structure represented by Fig. 5. appears to possess many advantages for bridges of that modified extent, and the manner of fixing the catenarian chains is applicable to all bridges of suspension; it is likewise new, so far as we know.

Strength of Iron.—The writer of this article has had oc-

casion, professionally, to examine the strength of iron, as a material which enters largely and essentially into the construction of bridges of suspension. He has also considered its laws of expansion, and other points bearing upon this important subject,—but without entering at present upon these topics, he must observe, that if we were to allow, universally, that a square inch of malleable iron is capable of sustaining a force equal to 27 tons, we should, in very many instances, overrate its powers.

From the valuable and highly interesting reports which have been made on this branch of the subject, by the Committee of the House of Commons, appointed for enquiring into the practicability of erecting a bridge over the Straits of Menai, the most important additions have been made to our knowledge regarding the strength of materials in this department of bridge-building. The very ingenious and effective methods also which have been adopted for proving the strength of iron, have been of the greatest consequence in forming the opinion of the engineer, and in verifying his experience. With machines of this kind, which we have seen in operation at the works of Captain Brown and Messrs Brunton in London, a force of upwards of 100 tons, is exerted with the greatest ease and facility, and with an exactness and precision which is altogether astonishing in experiments of such magnitude. By facilities of this kind, the chain-cable manufacturer is enabled, practically, to ascertain what each link, shackle and bolt will sustain, and he now proceeds with a degree of confidence and certainty in these matters, which, but a few years since, rested almost wholly upon hypothesis.

In one of these interesting trials at Messrs Bruntons' work on the Commercial Road, we witnessed some experiments with circular bolts of iron, to which a strain was progressively applied till the machinery indicated a maximum of 92 tons. In this experiment, when the strain had amounted to 60 tons, it was observable that small particles of the oxide of iron began to separate on the surface, and when the hydraulic machine was wrought up to a pressure of 75 tons, the part which ultimately separated and gave way, became sensibly smaller, its temperature was also somewhat encreased; and when the register of the machine indicated 92 tons, it suddenly parted or broke asunder.

This trial was made with a rod of Welch iron which Mr Brunton, on examining, and judging both from the strain applied, and the appearance of the fracture, concluded was not of the first quality.

It is hardly necessary, in chain-bridges of great extent, to observe, that no danger whatever is to be apprehended from the ordinary weight of the passing load. But, in projects of this kind, it becomes necessary to consult the safety of the fabric in extreme cases, by taking into calculation the crowded state of the roadway, when a multitude of people or a drove of cattle passes it. The former, however, we consider to be capable of inducing a greater weight, and of being much more dangerous, and perhaps less under controul, under certain circumstances, than the latter. We find that a given area, closely covered with men, will have a greater weight than the same space occupied by cattle, in the proportion of about 9 to 7; and every one knows that a drove of cattle is more likely to be gradually admitted upon the roadway of such a bridge, than a mob of people, whom objects of interest attract to any particular spot. Of this, a remarkable instance occurred at the opening of Captain Brown's bridge over the Tweed in July 1820, when it was intended to keep the roadway clear for the ceremony of the day; but this proved quite impracticable, and a crowd of people broke through every obstruction, and forced their way upon the bridge; and it was estimated, that at one time there were about 700 people upon the roadway. Now, taking each person and this number at 150 lb., it would give about 47 tons, besides its own weight which it sustained, without any apparent derangement.

The main chains of the Union Bridge, as we have seen, are formed of circular rods of iron, measuring about two inches in diameter; and a bar of that strength, which was not considered of the first quality, sustained a force equal to 92 tons. As the number of catenarian chains in the Union Bridge are twelve, if we estimate the strength of each rod, with its shackle, at 92 tons, we shall have the aggregate strength of the whole to be $92 \times 12 = 1104$ tons. We have already supposed the weight of the bridge, between the points of suspension, to be equal to 100 tons, and if to this we add 47 tons, as the greatest load which is likely to be ever brought upon it at once,

these together give 100 + 47 = 147, or say 150 tons. Assuming the angle of suspension at 12 degrees, we find that the real weight is increased to about 370 tons of tension on the catenarian chains. But as we find the strength of these chains to be equal to 1104 tons, there remains a surplus strength of about 734, or say 700 tons, to resist any emergency beyond a weight of 50 tons.

But the effect we have to provide against in bridges of suspension, is not merely what is technically termed *dead-weight.* A more powerful agent exists in the sudden impulses, or jerking motion of the load, which we have partly noticed in the description of Dryburgh Bridge. The greatest trial, for example, which the timber bridge at Montrose, about 500 feet in extent, has been considered to withstand, is the passing of a regiment of foot, marching in *regular time.* A troop of cavalry, on the contrary, does not produce corresponding effects, owing to the irregular step of the horses. The same observations apply to a crowd of persons walking promiscuously, or a drove of cattle, which counteract the undulating and rocking motion, observed on some occasions at the bridge of Montrose, when infantry has been passing along it. Hence also the effects of gusts of wind, often and violently repeated, which destroy the equilibrium of the parts of a bridge of suspension; and the importance of having the whole roadway and side-rails framed in the strongest possible manner.

Progress of Improvements.—It is not a little curious and interesting to trace the discovery and progress of improvements in the several departments of the arts and sciences, nor will it be considered foreign to our purpose, if we notice an instance or two of this kind. In the case of impelling boats by steam, for example, we know that this was first suggested and pointed out by Jonathan Hulls of England, about the year 1735, and was applied to practical and extensive use many years afterwards, in the United States of America (as noticed in the Annals of Philosophy, vol. xiii. p. 279.) It has also long been known, that chain-bridges of great extent have been erected in the Chinese Empire; and we have seen, that, about the year 1741, a bridge of this kind was constructed over the Tees, and has now formed a communication between the shires of Durham and York, for about

80 years. Here we have perhaps, again, been taught the more extensive application of this speedy and convenient method of crossing ravines and rivers, by the practice of our friends across the Atlantic.

To what extent this mode of bridge-building may be carried is very uncertain, and he who has the temerity to advance sceptical or circumscribed views on this subject, would do well to reflect upon the history of the Steam-Engine. When the Marquis of Worcester first proposed, by the boiling of water, to produce an effective force, no one could have conceived the incalculable advantages which have since followed its improvement, by our illustrious countryman, the late James Watt. Every one must also see the effect progressively produced on the public opinion, by the several propositions brought forward, and the bridges already executed upon the catenarian principle. When, for example, we pass from the slender wire-bridges on the Gala, the Etterick and the Tweed, and consider the advancement of chain-bridges from the Tees in 1741, to the Tweed in 1820, we look with confident expectation to the execution of the bridge over the Menai Strait, both from the well founded deductions of theory and practice.

The theorems on this subject, from the pen of Mr Gilbert Davies, (published in the London Quarterly Journal of Science, Vol. x., p. 230.), are equally satisfactory as they are elegant and simple; and although we may not be prepared, in practice, to go the lengths which theory would lead us, yet, we have no hesitation in stating it as our opinion, that the practical extent to which bridges of suspension may be carried on the catenarian principle, is by no means exhausted.

Edinburgh, 19*th July* 1821.

Art. II.—*List of Birds found in the district of Harris, part of the outer range of the Hebrides.* By Mr W. Macgillivray. Communicated by the Author.

The district of Harris is composed of rocky mountains and irregular eminences, with narrow valleys, and inconsiderable tracts of nearly plain land. The latter are, in general, covered with peat soil, in which the three common ericæ of Scotland are the predominant plants, associated with carices, scirpi, eriophora, and a few grasses: the former are in many places bare of soil and vegetation, not unfrequently heathy, and sometimes green with carices, junci, and the hard grasses, such as Melica cœrulea, Aira flexuosa, Nardus stricta, Poa alpina. The greater part of the country exhibits no marks of cultivation; and it is only along the shore that the small and unconnected portions of the cultivated land occur. This cultivated part is separated from the interior by dikes of turf or of stone, and it is called the part "within dikes." The interior is named "without dikes," that is, considered relatively to the hamlets or huts of the inhabitants, which are always on the sea-shore. The shore is irregular, formed into lochs, bays, and creeks; along the east and south coast rocky, on the west rocky in some places, and sandy in others. In each of the valleys there is one or more streamlets, but no considerable river is found in the whole district. The lakes are very numerous, and are all in the interior or uncultivated part. From the summit of one of the hills I have counted upwards of 120, the largest being nearly three miles in length, the smallest about forty yards. The lakes are commonly destitute of such plants, as afford food and shelter to aquatic birds. Hence the fresh-water birds are not numerous. The beautiful Nymphæa alba, the Lobelia Dortmanna, Menyanthes trifoliata, Potamogeton natans, Scirpus lacustris and palustris, Carex riparia and others, Sparganium natans, are the common lacustrine plants. The variety of plants which occur in the cultivated parts, particularly in those where sand predominates, is very great. They are precisely such as are found on the sandy tracts of the east coast of Scotland, about Aberdeen, for instance. This is the case also with regard to the maritime rupestrine plants. There are no woods or coppices; the

few specimens of stunted sylvan vegetation which occur, being found on the banks of the streamlets or lakes. These are of the following species: Pyrus aucuparia, Populus tremula, Corylus avellana, Betula alba; to which are added several species of Salix. The islets and circular rocks of Harris are very numerous. They are principally grouped in the channel between it and North Uist. The marine aquatic birds are numerous. The passerine tribe is scanty. The rapaces are also rare; but several species are found in greater abundance than in most districts of the Highlands or Isles: the Falco albicilla and F. fulvus. Of the Owl kind I have seen none. The Grallæ are not very numerous in regard to species; but the reverse in respect of individuals. Of Gallinæ there are only three species: the Columba œnas very numerous, the Tetrao attagen, and T. lagopus. Of Pici there are none,—of Coraces very few. The species of Corvus are the Corax and Cornix, both very common. The Rook is also an occasional visitant. The fresh water Anseres are not very numerous; but there are some of them rare in other parts of Scotland: the swan, for example, which is but an occasional and winter visitant. The Anas bernicla, A. erythropus, A. anser, very common; A. tadorna and A. mollissima,—the two last marine species. Herons are numerous. The snipe is very abundant, breeding on the heaths. The Tringa alpina of Lin., which I suspect, from actual inspection, to be his T. cinclus in its summer plumage, breeds in great numbers on the heaths, and is to be found with the Charadrius pluvialis, which is very numerous. Lari are very abundant, both in regard to individuals and to species. Distinct in form and habit, they ought, perhaps, to be separated from the true aquatic birds. They are intermediate between the Anseres and Urinatores (divers or sharp-billed aquatic birds), and the Grallæ. The genera Larus, Sterna, and Procellaria, are examples. To which I would add the Pelecanus Bassanus, which is very palpably distinguished from P. carbo, or P. graculus, by peculiarities of formation, such as having its mandible composed of several bones, and of manners, agreeing in both with the Lari. Of Levirostres and Struthiones, there are, of course, none. The Anseres, then, are the most numerous; next to them the

Grallæ; then the Passeres, Accipitres, Coraces, Gallinæ. These according to Blumenbach's arrangement.

In the following enumeration of the Birds of Harris, the Linnæan names are used. The names of the birds which remain always in the country are printed in common characters; those which are migratory, in the Italic character.

Instead of giving a mere list, I shall arrange the birds according to their usual habitations, or places of feeding, (their nidification not being considered).

Land and Sea obviously form the first divisions. The latter admits of only two subdivisions; the open sea, and that along the coast. The former I divide into Fields, Hills, and Shores. The division Lakes and Rivers is an adjunct to the two former; that of Corn-yard to the first. The department Fields includes the varieties of ground usually found "within dikes," which may be divided into dry and wet. That of Hills includes all "without dikes," consisting of hills and valleys covered with heath, and divisible into dry and wet, as the former. The shores are rocky and sandy.

The list is imperfect; but, in so far as it goes, is certain. The Pelecanus graculus and cristatus, I deem the same bird. Falco albicilla and ossifragus; Larus marinus and fuscus; Colymbus troile and minor. Tringa cinclus and alpina, and the Lari, are all in confusion, on account of the variety in their plumage, which is not permanent till the third year.

LAND.

FIELDS, *Dry.*—Alauda arvensis, Alauda pratensis, Fringilla linota, Columba œnas, Emberiza calandra, Turdus musicus, Sturnus vulgaris, Scolopax arquata, Corvus corax, Corvus cornix, Motacilla troglodytes, Turdus merula, Emberiza schœniclus, Larus canus aliique, Charadrius pluvialis, Anas anser, Anas bernicla, Anas erythropus, Motacilla modularis, Falco milvus.

Scolopax phœopus, Hirundo riparia, Rallus crex, Fringilla nivalis, Motacilla alba, Motacilla flava, Cuculus canorus, Motacilla œnanthe, Turdus pilaris, Turdus iliacus.

Wet.—Scolopax gallinago, Anas boschas, Rallus aquaticus, Scolopax gallinula.

Tringa vanellus, Scolopax rusticola.

HILLS, *Dry.*—Tetrao attagen, Charadrius pluvialis, Corvus corax, Tetrao lagopus, Larus marinus, Turdus musicus, Turdus merula, Motacilla modularis, Motacilla rubetra, Emberiza schœniclus, Falco albicilla, Falco fulvus, Falco ?

Wet.—Scolopax gallinago, Anas boschas, Tringa alpina, Rallus aquaticus.

Scolopax rusticola.

SHORES, *Rocky.*—Larus marinus, Larus canus, Larus nævius, Larus hybernus, Scolopax arquata, Hæmatopus ostralegus, Scolopax glottis, Scolopax calidris, Charadrius pluvialis, Turdus musicus, Alauda pratensis, Tringa morinella, Tringa nigricans, Ardea cicinerea, Corvus cornix, Falco albicilla.

Larus rissa, Larus ridibundus, Sterna hirundo.

Sandy.—Larus marinus, Larus canus, Larus nævius, Larus hybernus, Larus parasiticus, Scolopax arquata, Scolopax glottis, Scolopax calidris, Charadrius pluvialis, Charadrius hiaticula, Charadrius calidris, Tringa morinella, Falco albicilla.

Sterna hirundo, Emberiza nivalis, Larus ridibundus, Anas tadorna.

RIVERS.—Sturnus cinclus, Rallus aquaticus.

LAKES.—Colymbus septentrionalis, Pelecanus carbo, Anas boschas, Anas anser, *Fulica atra,* Fulica chloropus, Anas crecca, Anas clypeata.

Anas bernicla, Anas erythropus, Anas cygnus, Tringa hypoleucos.

CORN-YARD, and about HOUSES.—Fringilla linota, Emberiza calandra, Alauda arvensis, Sturnus vulgaris, Emberiza schœniclus, Turdus musicus, Motacilla modularis, Motacilla troglodytes.

SEA.

By the Shore.—Pelecanus carbo, Pelecanus graculus, Pelecanus cristatus, Colymbus arcticus, Colymbus stellatus, Colymbus septentrionalis, Colymbus grylle, Colymbus glacialis.

Pelecanus bassanus, Mergus serrator.

Open Sea.—Procellaria pelagica, Procellaria glacialis, Larus cinerarius, Anas glacialis, Anas scoter, Colymbus grylle, Anas mollissima.

Alca torda, Pelecanus bassanus, Anas glacialis, Alca arctica, Alca torda, Alca pica, Colymbus Troile.

Accipitres.

Falco albicilla
F. fulvus
F. milvus
Falcones tres incog.

Coraces.

Corvus corax
Corvus cornix
Cuculus canorus
Corvus frugivorous occasional

Passeres.

Alauda arvensis
Alauda pratensis
Sturnus vulgaris
Sturnus cinclus
Turdus pilaris
T. iliacus
T. musicus
T. merula
Emberiza nivalis
E. schœniclus
E. calandra
Fringilla linota
Motacilla modularis
M. troglodytes
M. alba
M. flava
M. rubetra
M. œnanthe
Hirundo riparia?

Gallinae.

Tetrao attagen
T. lagopus
Columba œnas

Grallæ.

Ardea cinerea
Scolopax arquata
Sc. phæopus
Sc. rusticola
Sc. gallinago
Sc. gallinula
Sc. glotti
Sc. calidris
Tringa vanellus
T. morinella
T. alpina
T. cinclus
Charadrius hiaticula
Ch. calidris
Ch. pluvialis
Hæmatop. ostralegus
Fulica atra
F. chloropus
Rallus crex
R. aquaticus

Anseres.

Sterna hirundo
Colymbus grylle
C. troile and minor
C. septentrionalis
C. arcticus
C. stellatus
C. glacialis
Larus rissa
L. hybernus
L. canus
L. cinerarius
L. nævius
L. marinus
L. ridibundus
L. parasiticus
Procellaria pelagica
P. glacialis
Pelecanus carbo
P. graculus
P. cristatus
P. bassanus
Anas cygnus
A. nigra
A. anser
A. erythropus
A. bernicla
A. boschas
Mergus serrator
Alca arctica
A. pica
A. torda
Anas mollissima
A. clypeata
A. glacialis
A. crecca

Art.—III. *Analysis of Mr* Barlow's *Essay on Magnetic Attractions.*

In our number for October 1819, we gave a brief sketch of the results of a series of very interesting magnetical experiments, carried on at the Royal Military Academy, by Mr Barlow. An account of these experiments has since been published, under the title of an "Essay on Magnetic Attractions."

It appears that the apparatus which Mr Barlow employed for conducting this course, consisted, first, of a solid iron-ball, of nearly 13 inches diameter, weighing about 288 lb. This was suspended by a system of pulleys, which enabled the experimenter to raise or lower it at pleasure. Immediately under the ball was placed a strong, firm, round table, about 5 feet in diameter,

having a hole in its centre, through which the ball might be made to pass when required. The plane of this table was divided into equal portions of 2¼° each, and properly numbered, proceeding from the line forming the magnetic meridian; and the whole rendered perfectly secure and steady, by placing the apparatus on piles driven into the earth, through the floor of the model room of the Royal Military Academy at Woolwich. With this machine, it is obvious, the compass might be placed at any azimuth from the magnetic meridian; at any distance from the centre of the table, and the ball itself placed at any height above, or depth below, the plane of the table.

We have already stated in our second number, in the article above alluded to, that Mr Barlow had, prior to these experiments, discovered that there exists in every ball of plain unmagnetized iron, a plane of no attraction, which passes from north to south, and forms, in these latitudes, with the horizon an angle of about 19½°, as the complement of the dip; and his first course of experiments is accordingly directed to the confirmation of this fundamental fact. The result of these experiments gives for the mean inclination of the plane 19° 24′; and the actual dip, as determined by an excellent dipping needle, is in the same place 70° 30¾′, of which the complement is 19° 29¼′, leaving an error of only 5¼′, which is probably to be attributed to the daily variation, or to defects in the instruments, and errors of observation.

Before we proceed farther in our analysis, let us examine how far this result, which the author has certainly put in a strong point of view, may be considered as a newly discovered fact.

For more than two centuries it has been known, that if a bar of soft iron be placed vertically, or nearly so, in these latitudes, its lower end will become a north pole, and its upper end a south pole; that is, the lower extremity of the bar will attract the south end of the needle and repel the north; while, on the contrary, the upper extremity will repel the south, and attract the north end of the needle. It may, therefore, easily be imagined, that if a needle were made to descend vertically near such a bar, it must pass through a point where the effect of the bar will vanish, and this will be the case in every vertical, whatever may be its azimuth and distance. But the question is, Had any one

before Mr Barlow attempted to connect these several points with each other? Was the surface formed by the union of those points investigated? Was it known whether this surface was a curve or plane? And what was its position either with reference to the bar or to the horizon; and how did its position change in different latitudes? We believe that no one of those questions could have been answered prior to Mr Barlow's experiments.

He has first shown, that these several points of no action fall in one plane, and that that plane always forms with the horizon an angle equal to the complement of the dip. It must therefore, we conceive, be admitted, that, in this determination, he has made a considerable step towards reducing to definite laws the hitherto apparently uncertain action of unmagnetised iron.

We have been the more particular in examining this question, because it appears, by a letter lately published by the author, that some attempts have been made to show that there was no novelty in this deduction.

In order to pursue his inquiries further, Mr Barlow imagined the circle cut off by the plane of no attraction, from a ball of iron, or any sphere concentric with it, to form an equation; and hence, by means of imaginary circles of latitude and longitude, (the first circle of the latter passing through the east and west points of the horizon), he was enabled to designate the situation of his needle in that sphere, which, together with the distance from the centre, answered all the purposes of three rectangular co-ordinates, by which positions in space are commonly determined.

Having made the requisite computations for this purpose, he caused the compass to be moved round the ball in different circles, first, in those in which the longitude was zero, or a constant quantity, in order to obtain the effect due to latitude only; then in circles of which the latitude was constant, in order to obtain the effect due to longitude only, the distances remaining constant; and in this manner he obtained the simple law expressed by the following formula, viz.

$$\text{Tan. } \Delta = A \sin. 2\lambda \cos. l.$$

That is, the tangent of deviation is proportional to the rectangle of the sine of the double latitude and the cosine of the longitude.

The next object was to determine the law for the distance, with which view the same series of experiments were performed at four different distances, viz. 12, 15, 18, and 20 inches; and applying to these results the method of *minimum square*, the author obtained, in the most satisfactory manner, the following conclusion; viz. that all other things being the same, the tangents of the angle of deviation are reciprocally proportional to the cubes of the distance. And, lastly, by using balls of different diameters, he found the tangents of deviation proportional to the cubes of the diameters. The general formula for expressing the deviation under every circumstance is therefore,

$$\Delta = A \frac{D^3}{d^3} \left\{ \sin. 2 \lambda \cos. l. \right\}$$

where Δ is the angle of deviation, D the diameter of the base, d the distance, λ the latitude, l the longitude of position, and A a constant factor to be found by experiment.

But the most remarkable discovery of the author still remains to be noticed. We have stated that he found the tangents of the angles of deviation to be proportional to the cubes of the diameters, whence it was natural to conclude, that they were proportional to the masses; and he had, in fact, come to this conclusion, when he fortunately made trial of a ten-inch shell, and found that it gave precisely the same deviations as the solid ball of the same dimensions. This led to a new course of experiments on balls, plates, and shells of iron, of various thicknesses; and he thus ascertained that the attracting power of iron bodies, for the magnet, resides wholly in their surfaces, and that it is independent of their masses, provided their thicknesses exceed a certain quantity, (probably about $\frac{1}{20}$th of an inch.)

Lastly, as the laws we have been enumerating were all deduced from experiments on balls and shells, he was next desirous of ascertaining whether they obtained equally on irregular masses; and, with this view, a series of experiments were made on an iron 24-pounder, mounted on a traversing carriage and platform, which, together with its iron trucks, &c. weighed 58 cwt., on which the laws were still found to be the same as on the most regular body; and hence it followed that they might be made immediately applicable to the correction of the local

attraction of vessels, the object for which the course of experiments was specifically undertaken.

Aware, however, of the consequences of introducing difficult computations into the daily reckonings of a ship's course, the author endeavoured to discover some method of performing the same experimentally; and, after one failure, he succeeded in every respect to his wishes; although it appears, by the letter to which we have already alluded, that he has since still further improved the method described in his Essay; and that he has, by an order of the Admiralty, put this method in practice on board his Majesty's ships the *Leven* and *Conway:* and we understand that Captain Parry takes out one of his correcting plates in the *Fury*, in the present voyage, where the efficacy of the experiment will be submitted to a severe, but to a candid trial.

We have no hesitation in stating, that, as far as our knowledge of magnetism extends, all the laws which we have been describing are new facts in that science. By means of them we may compute, and by the most simple rules, the effect which a mass of iron will produce on the compass in every situation, and in any part of the world; and we ask, Could this have been done prior to Mr Barlow's discoveries?—and if so, In what works are those laws given?

We insist upon these questions, because it appears that some attempts have been made to show that there is nothing strikingly new in these results. In the letter already alluded to, Mr Barlow says,—

"It is pretty generally known, that soon after I had arrived at the leading principles of the above laws, I communicated the results to the Royal Society, and that the Committee refused publishing my memoir, assigning (as I have found since my book has been published) as a reason, that similar experiments had been made in Denmark many years ago.

"This is stated in a letter from the late Sir J. Banks to the late General Mudge, of which the following is a copy."—"*Soho Square, May* 13. 1819.—My dear Sir, I have received Mr Barlow's paper, and have placed it in the hands of the Secretary of the Royal Society, to be read at the first meeting. It gives me much satisfaction to see that experiments have been

made by Mr Barlow on the subject. I find, however, that some experiments somewhat similar have been tried in Denmark many years ago. The results I have not yet obtained, being ignorant of the Danish language, in which they are recorded, but I hope to obtain a translation in a few days.—" Most faithfully your's, (Signed) Jos. Banks."

After waiting some months, and receiving no other information from the Royal Society, Mr Barlow seems to have communicated the contents of the above letter to Professor Schumacher of Copenhagen, requesting to be informed whether any such experiments were recorded in any Danish work he was acquainted with, and the following letters from Commodore Wleugel and Professor Schumacher, seem very decisive in favour of Mr Barlow's claims.

From Professor Schumacher to Mr Barlow.—" Dear Sir, I have just received the Edinburgh Philosophical Journal, and found an account of your experiments. However, I was aware that such experiments never had been made here; I requested my worthy friend the Commandeur Wleugel, who has applied himself with great success, particularly to these studies, to give his opinion of it, if they were new or already made here. You will find that your experiments never were made in Denmark." " Your very obedient servant,

(Signed) " Schumacher."

From Commodore Wleugel to Professor Schumacher. (*Translation.*)—" Though there have been made experiments in Denmark, not only on the effects of considerable masses of iron on the needle, but also on the mutual influence of magnets, yet, experiments similar to those published in the Edinburgh Philosophical Journal, No. 2, October 1819, page 344, *et seq.* and several of the results deduced from them, never have been publicly known before in this country, which I herewith testify."

(Signed) " P. W. Wleugel,

" Commander in the Royal Danish Navy, Examiner at the Royal Naval Academy, Director of Navigation, Knight of the Order of Dannebrogen."

" *Copenhagen, June* 16. 1820."

After this digression, which we thought it but just to make in favour of Mr Barlow's claims, we proceed in our farther ana-

lysis of his work. The leading principle of the preceding laws, and that upon which they all rest, is the existence and particular position of the plane of no attraction, which, as we have seen, forms in Woolwich with the horizon, an angle equal to the complement of the dip; and generalizing from this individual fact, Mr Barlow concluded that it was the same in all parts of the world; consequently, on the magnetic equator, that plane will be perpendicular to the horizon, and a ship being put round in this place, ought to pass through four points of no attraction, viz. at E. W. N. and S.; whereas, hitherto, the two former had been considered as the points of greatest attraction in all parts of the Earth.

This, however, could only be considered as a probable conjecture, till experiments had been made to verify it; and it must therefore have been peculiarly gratifying to Mr Barlow, to find his views so fully and satisfactorily confirmed by the experiments of Mr Lecount, of which an account will be found in a future article of this number *. These experiments were made without any knowledge of what had been done by Mr Barlow, and are therefore the more satisfactory and conclusive.

In the last two sections of his Essay, Mr Barlow indulges himself in some speculations of a theoretical nature, which will probably share the fate of various other hypotheses that have been from time to time advanced, to account for this mysterious action; the first relates to the course of the diurnal variation of the needle, and the other to the general principle of magnetic action; or rather, perhaps, we should say, that, in this last section, he has endeavoured to throw some doubt upon the present received doctrine, without advancing any new theory in its place, except slightly alluding to certain theoretical views of his colleague Mr Christie, of which a more particular account will be found in our present number.

The author seems unwilling to admit that doctrine, which makes every mass of soft iron a magnet, from the action of a supposititious terrestrial magnet, and it must certainly be admitted to want one of the most essential characteristics of such a body. A magnet, whether natural or artificial, however weak,

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* See page 295. of this No. and also Vol. iv. p. 436.

will not only disturb the direction of the magnetic needle, but it will suspend pieces of soft iron of greater or less dimensions, according to its size and power; but a body of pure iron, however large, and although it will disturb the needle at considerable distances, will not hold suspended the slightest particle of iron dust, and is thus, we think, sufficiently distinguished from a magnet properly so called. Mr Barlow also objects to the doctrine of the earth itself acting as a powerful magnet, supporting his objection by the well known computation of M. Biot, who has shewn that such an action cannot obtain, unless we consider the two magnetic poles of the earth as coincident in its centre, which is an obvious absurdity. Indeed, we think it by no means improbable, that the magnetic action of soft iron will, ere long, be found to differ from that of actual magnetized bodies, in the same degree as the electric currents of the galvanic apparatus differ from the intensity of that fluid when excited by an electric machine, and the action of the earth will probably be found to belong to the former class.

Art. IV.—*Observations on the Countries of Congo and Loango, as in* 1790. By Mr Maxwell, Author of the Letters to Mungo Park, &c. &c. (Continued from p. 53.)

Monkeys.—THE number and variety of the monkey species in these countries is beyond conception. Myriads of a small black kind with white breasts, about the size of a Cat, assemble every morning upon the lofty trees overhanging the brink of the Congo, in the neighbourhood of Oyster Haven and Maccatala, to drink. At these times it is amusing enough to observe with what celerity they make their retreat, causing the woods to resound with their chattering, at the report of a musket. Upon the highest trees they generally build their nests, which, in form and construction resemble those of the magpie, but are much larger, and made of dry grass. The entrance is a round hole in the side. The upper part is covered with grass to a considerable height, to keep out the rains.

Poongo.—The most wonderful animal of the genus Ape, is the Poongo. When walking erect, it measures six feet, and

is said to have the strength of ten men. In this case, were it equally ferocious, it might reign the undisputed sovereign of the woods. In fact, according to the natives, it is an overmatch for all the beasts of the forest, drives the elephant before it with clubs, and frequently carries off their women, when it meets them at a distance from home.

Chimpainzee.—This is known to Europeans as the Oran Outan, or Wild Man of the Woods. In point of size, strength, and sagacity, it is very different from the Poongo. It is of a more gentle nature, and is easily caught and tamed. Captain Fairweather brought one from Old Callabar, but it died on the passage from the West Indies to Liverpool. I was told by an eye-witness, that it used to take its bed upon deck to air,—would tie a handkerchief about its head, as if sick,—formed a partiality to some of the officers,—made use of a cup and saucer when taking tea,—peeled an orange with a knife,—wiped its mouth with a cloth,—all in a very methodical manner. Many attempts have been made to bring them to England, but they cannot endure the cold of our climate. They have never been known to utter articulate sounds.

Antelope.—The Antelope is about the size of the common deer. As an article of food, it contributes much to the support of the inhabitants. The flesh is prepared and seasoned with Palm-oil, salt, and Cayenne pepper, and is then called Sylla mamba. The skin is used for various purposes.

The Antelopes are seen at times in such immense herds, as almost to exceed belief. Once, about the middle of November, when dropping down the river, I was gratified with a most interesting sight; the whole country between Taddi-lem Weenga and Ganga Empeenda, a distance of five leagues, was covered with Antelopes down to the river. We fired several rounds of cannister shot at them, but apparently without effect. The mountains on this bending reach of the river, recede considerably inland, forming a beautiful amphitheatre, over the sloping surface of which the Antelopes had spread themselves. Were I, at a venture, to estimate their numbers at 30,000, I should conceive myself far within bounds; for that would not give above 600 to a square mile,—a small number considering the appearance they made. It must be remembered, however, that, as

seen from the ship, their numbers appeared to the greatest possible advantage; but, on the other hand, we may suppose that the undulations of the ground concealed many of them from view.

With the exception of a clump of aged trees here and there, which gave a high finishing to the landscape, the whole of this slope was free of brush, or any other sort of wood. The withered grass had been burned down in October, and was now succeeded by luxuriant herbage of the most lively green, which, although very little rain had fallen as yet, had sprung astonishingly in length, and presented an appearance like the wheat crops of Britain when covering the clod,—an adequate invitation no doubt, for the vast herd that browsed upon it.

On the steep banks of the river, the natives have formed inclined landing places for their own convenience. Here, when the wild animals are under the necessity of coming to quench their thirst in the dry season, they conceal themselves, and when an Antelope enters the narrow pass, they appear behind and drive it into the water, where it is soon dispatched by people stationed in canoes for that purpose.

During the dry season, large hunting parties are formed, who surround the place where the greatest quantity of game is known to be, and set fire to the withered grass. The flaming circumference of the circle diminishes with noisy rapidity, emitting so intense a heat, that no animal dares to attempt a passage. An opening, therefore, is purposely left, at which the most expert marksmen are stationed, who generally kill a sufficient quantity.

Another mode of hunting the Antelope, only had recourse to when the grass cannot with safety or convenience be set on fire, is to encircle an entire district with a cordon of people, at proper distances from one another. Each individual is provided with a piece of red cloth, which he fastens to the end of his spear, and waves it over his head. In this manner, the whole circumference advances as towards a centre, and with shouts and cries at last coops up the terrified animals within a very small space, where great numbers are killed whilst attempting to escape.

Buffalo.—The Buffalo is sometimes hunted, but he becomes so furious when wounded, that it is considered a very dangerous enterprise, and is therefore seldom engaged in.

Chacal.—The natives have contrived to domesticate a species of Chacal, which, however, is of very little use to them, and very ugly; nevertheless, they take it with them to the chace.

Hippopotamus, or River-Horse.—The natives hunt this animal with much eagerness for its flesh, which they esteem excellent food. I was one day presented with a piece which had just been killed. It was coarse and bitter; probably however, some of the gall had been diffused over it: the young ones may be delicate enough. It is an amphibious animal, and associates in herds. I have sometimes seen a groupe of fifty basking in the sunshine, and half covered by the shallow water of a sand-bank. At such times being frequently asleep, the natives steal cautiously upon them in canoes, but seldom succeed in surprising them. They remain so long under water when disturbed, that it would be difficult to discover a wounded one, were it not for a float attached by a line to the harpoon. This points out his retreat, and where he will re-appear to breathe. There are two tusks in each jaw, which yield very valuable ivory.

When they have cropped all the herbage upon the low islands, and on the margin of the river, they go on shore during the night to graze, and are caught in pits, dug in their most frequented paths, and covered over with branches.

I never had the good fortune to kill a Hippopotamus, although I have often attempted it by muffling the oars and warily approaching them, but they always took the alarm, and retreated to deep water. This inclines me to think, that one of their number stands centinel whilst the others sleep. They presented, however, many opportunities of being fired at, rearing their huge heads abruptly out of the water, sometimes only a few yards from the boat, putting us under no small apprehension by their tremendous bellowing and threatening aspect. Many a volley was fired at them, but whether the hide was proof against ball, or the current carried the wounded out of our reach, we could not ascertain.

One morning I dispatched my chief mate, Shimmons, who augured better success with the harpoon, upon this employment. When he reached the shoal, where the Hippopotami had been observed basking, he discovered one of them by the motion of the water, and accordingly darted the harpoon at it with his ut-

most force. The animal was probably wounded by the stroke, for it gave the boat such a kick, that the mate was thrown overboard, but was instantly rescued from his perilous situation by the crew.

The coincidence between the description of Behemoth in the Book of Job, and the habits of the Hippopotamus, is so remarkable, that whoever studies the subject must be satisfied they are one and the same animal.

Fishing.—This forms a principal part of the amusement and resources of the great men who live in the vicinity of the Congo. At certain seasons, they repair with a considerable retinue to the Mangrove forests skirting the river, where they establish their quarters. The bland air enables them to dispense with any other covering than that afforded by the trees, which shade them completely from the sun; and, if necessary, an ample cloth-belt secures them from cold. A few earthen pots to dress their victuals in, with skins and mats for the better sort to lie upon, are all their furniture. The mode of fishing is very ingenious. Having fixed upon a shallow channel between the shore and some sandbank or island, a row of stakes is driven across to support a frame of wicker work about three feet high. A small opening is left where the water is deepest, in which a trap, resembling a bird-cage, is placed. Into this the fish enter in great numbers, and are taken. The women and children are employed in smoking them for the rainy season.

The fishing on the coast of Angoya (or Cabenda,) is conducted in a different manner, and upon a very extensive scale. They use a net or seine nearly four hundred fathoms in length, and three or four in depth, made of strong materials. It is floated by buoys of the Lob-lolly tree,—a soft spongy wood, used also for harpoon floats. A sweep is made along the shore with this net, which seldom fails to bring out a large draught of mullet and other fish, with which these coasts are well stored. There is abundance of very fine rock-oysters, which adhere to one another in hundreds, and can only be come at by being knocked in pieces. Rock-cod, snappers, and soles, are very plentiful. The two former are of a reddish colour, and are accounted delicate eating.

Electrical Fish.—Happening one day to see a fish struggling on the surface of the water, as it floated past the vessel, I sent the small boat for it, and when alongside, a rope was handed down to haul it upon deck. The sailor who was fastening the rope started back in the greatest consternation, exclaiming with an oath, that he believed the Devil was in the fish. This induced me to examine it attentively, and I perceived that the cause of the man's astonishment was an electric shock proceeding from the fish. Before each shock, the skin upon its back and sides became very tense. It was like a Cod, and weighed about thirty pounds. I gave it to the natives, who were commending it much.

Turtle.—There is a species of black turtle in the Congo, weighing about sixty-five pounds without the shell. It has a longer neck than the sea-turtle, with a long slender tail, and an ugly rough skin. It is thought excellent food by the natives and the French. This may be true enough, notwithstanding its disgusting appearance; but every one knows that the latter people are not very nice in the choice of their viands, provided they will enter into the composition of a Friccasee or Ragout.

Crocodiles.—These are very numerous in the river, and the natives say voracious; but they do not seem to dread them; on the contrary, I have observed people bathing where crocodiles were swimming a short time before. They may be seen every hour of the day, sunning themselves upon the sandbanks. They appear, however, to be of a smaller species, and not so numerous, as at Old Callabar, where they continually float past the shipping like large grey pieces of timber, and are there so bold that they frequently seize people in the small canoes. In Old Callabar River, I once observed a crocodile swimming with a large Cat-fish in its mouth, to the opposite shore. It held the fish by the head, whilst the body was thrown into a perpendicular position. I watched it with the spy-glass until it had dragged the fish upon the mud-bank, and commenced its meal. A party armed with muskets was then dispatched from the ship, to kill it, but on the approach of the boat, it retreated to the water with the fish in its mouth. From this I am induced to think that the crocodile cannot devour its prey in the water.

Seebisee.—Upon the low islands in the river, a small animal resembling a rat, but much larger, is found. It has two long cutting teeth before, and is covered with bristles like those of a hedge-hog. It burrows in the sandy soil. The natives, who call it Seebisee, and the French, esteem its flesh a great delicacy. Unfortunately, however, we recollect, that Frenchmen pay the same encomiums on rats and frogs. Nay, they go further, for I have frequently seen Carrion exposed to sale in the country markets of Brittany.

Bats.—There is a large species of bat, measuring thirty-four inches between the wings, when extended, and ten inches from the nose to the tail. It harbours about the Palmetto trees, and lives upon the fruit, which is about the size of a large Orange, but not eaten by the natives. I have seen some hundreds of these bats fly out from a single tree; and, when on the wing, they appear as large as Crows. They are very fierce and vicious when wounded.

Frogs.—During the night, the banks of the Congo, in the neighbourhood of Embomma, are perfectly alive with innumerable numbers of Frogs, and other noisy reptiles, which keep up an incessant croaking until morning. They are, I suppose, what is called the Bull Frog.

Boa Constrictor.—Once when lying in the river, and hearing an unusual noise overhead, I hastened upon deck. The natives, of whom a number were on board, were calling out *Bomma! Bomma!* Those on shore were running from the landing-place in the greatest terror. The cause of this alarm explained itself. A large Snake was floating close past the vessel. It was a Boa Constrictor. I immediately manned the yawl, and went in pursuit, foolishly thinking that if I could but fix a harpoon into it, the force of the current would prevent its boarding the boat. Imagining it to be asleep, I approached slowly, to have an opportunity of striking it, to the best advantage, but soon discovered that it was dead. I hooked it with the harpoon, and drew it alongside; but when on deck, the stench was so intolerable, that we were obliged to throw it overboard. It was quite flaccid; and, although the entrails were out, the diameter of the body in that state was nine inches. The extremities had been cut off, and only fourteen feet of the trunk left; but as this part ta-

pered nothing at either end, we may reasonably conclude that the whole body was at least three times that length. Here, then, is a Snake fifty feet long, and almost a foot in diameter! Its probable dimensions need not surprise us,—there are so many well-authenticated accounts of the enormous size to which these reptiles attain. The natives spoke of this as a very small one. The skin was a quarter of an inch thick, and had beneath it a deep layer of fat. It was covered with large serrated black and dusky coloured spots across the back. The belly was white.

The Autumnal Conflagrations frequently prove destructive to the Boa Constrictor, especially when gorged with its prey; and it is only then that the natives dare attack it with any hopes of success. At other times it will make a whole village fly before it. Its name in the Loango tongue is Bomma, whence *Embomma*.

(*To be continued.*)

ART. V.—*Account of Water-Spouts observed at Sea on Voyages to and from India.* By FRANCIS BUCHANAN, M. D. Communicated by the Author.

ON the 24th May 1788, at half past four in the afternoon, a water-spout was seen in the SE. Upon going to a window, I found that it had disappeared, but a dark, thick cloud hung over the sea in that quarter, at an elevation of about 20 degrees. Beyond that cloud the sky was not clear. Soon after coming to the window, I observed a curved spout come from the cloud, as shewn in Plate IX. Fig. 1. *b*, the concavity of the curve being to windward. At the same time, or at the next moment after observing the spout, I perceived a thick cloud or fog arise from the sea, *c*. Very soon afterwards, the spout rushed down and joined the cloud, which had arisen from the sea; and, at the same time, this rose higher, and contracted its diameter, as in Fig. 2.

The water spout being now completely formed, the appearance of it was as follows: The cloud *a*, from which the spout descended, moved slowly along, and probably, by this means, produced the curvature in the spout. The body of the spout *b*, tapered gradually downwards, and was seemingly

more dense than the cloud from which it descended, but not more dense or black than clouds often are. The fog coming from the sea was of the same colour as the spout, and resembled the smoke of a steam-engine. During the whole time, the surface of the sea under the spout was evidently in violent agitation, and full of white waves; at the same time a noise was heard, like that of an immense waterfall. From the formation of the spout, till the time it reached the cloud arising from the sea, appeared to be about two minutes. The spout then began to withdraw itself into the cloud, from whence it had descended; while the cloud below gradually withdrew into the sea; and in about three minutes all was over, and the thick cloud in the sky, in a short time, was entirely dispersed. The distance of the spout from the ship appeared to be rather more than a mile. I had no opportunity of examining it with a glass.

With regard, however, to the distance of elevation and duration of the spout, I must acknowledge that I am very uncertain, as I only reckoned by guess, and others in the ship differed very considerably from me in their opinion, both with regard to these points, and also respecting some others. Some thought, that it lasted at least ten minutes: some that it was not half a mile off; some that the cloud did not rise from the sea, till the spout reached the surface of the water; and some even thought, that it was not a cloud that arose, but a body of water, and that the spout was a solid column of water whirling about with great velocity. In these last opinions I put very little confidence, knowing with what little attention people are apt to view natural appearances, when the mind is misled by preconceived notions, and occupied by attention to other affairs, as the persons alluded to were employed in the means proper for the preservation of the ship. Of this I am certain, that the cloud rose from the sea, and met the descending spout; and that I looked very anxiously to discover a whirling motion, but to no purpose.

At noon we had been in Lat. 20° 45′ S., and from that time had gone very little. Our Long. was nearly 20° W. from Greenwich. For two or three days the weather had been very unsettled, the wind seldom remaining two hours in one quar-

ter, and sometimes blowing hard, at others sinking into a calm. Sometimes the sky was clear, and at others it rained heavily. We had frequent thunder and lightning, especially on the evening after seeing the spout. At the time of the phenomenon there was little wind at the ship, and that was from the NW.; but at the spout, if we may judge from the motion of the clouds, there was a pretty strong breeze at SW. It rained heavily at the ship, but the shower extended only a little way. The thermometer in a cabin on the gun-deck was at 75°, but in the open air would have been three or four degrees lower.

On the 8th of January 1789, at half-past eight in the morning, we observed like a thick cloud resting on the sea, Fig. 4. *a*, and bearing from us W. by N. from four to six miles distant. It was not very dense, and resembled a ship when hull-down. Over it a thick cloud hung at an elevation of about 30°. To the southward of it there was a heavy rain, *b*. There was at the ship a pretty little breeze at S., which continued for some hours. The captain first observed this cloud from the round house. A spout then came down from the cloud in the form of an elbow; but before he gave me notice, the spout had disappeared, and nothing remained except the cloud on the water.

About half an hour afterwards I was informed, that the spout had returned. Upon coming on deck, I observed the cloud Fig. 3. *a*, and the rain *b* as before; and a new spout was then formed, where the former had been. The spout *c* was cylindrical, and slightly bent by the wind to the north. Below it terminated in a point about 300 feet from the sea; above it was suspended from the cloud, but became rather narrower, having sent off two branches *d*, *d*. It was every where of a defined form, and much of the same density with the cloud. In looking at it with a glass, I at first took it to be hollow; but I soon discovered, that this was owing to the middle appearing lighter than the sides, as it must do from the known laws of optics. From the sea arose a circumscribed conical cloud *e*, nearly of the same density with the spout. After continuing about ten minutes by a watch, the spout and both clouds became gradually lighter coloured, till they entirely disappeared. The rain to windward continued all the while, and seemed near-

ly as dense as the spout. No noise was perceptible. We were then in about Lat. 3° 38′ N. and Long. 135° 26′ E. from Greenwich. The weather was very unsettled, as is usual in such latitudes. The Thermometer was at 82°. We had no thunder nor lightning that day. The sky was every where full of irregular clouds, with frequent showers. With regard to the distance of the water-spout, I conjectured that it was at least six miles off, as I thought that its base was beyond our visible horizon. As for the altitude of the cloud, I only conjecture that it was 30°, and I may readily be mistaken 5° or 6°.

April 12. 1789, being in the Southern Atlantic Ocean, at half an hour past eight in the morning, I observed the base of a water spout Fig. 5. *a*. It was situated so near a squall of rain *b*, that, before the top had time to form, it was enveloped by the squall. It bore SW. from the ship. Soon after, the officer on deck observed a spout in the same quarter descend from the cloud, half way to the water. At nine, coming on deck, the officer informed me that a spout had formed in the same place, had then withdrawn for a minute or two, and had now again descended. Upon looking, I observed it at *a* coming down from a pretty high cloud *d*, as in Fig. 6., and reaching half way to the water. It was bent in a direction from E. to W. When I examined it, the centre appeared much lighter coloured than the sides, owing most probably to its being cylindrical. Under its lower extremity the water was highly agitated as at *b*, and white, as the water under a cataract is. From the space so agitated, a thick spray or fog arose at *c*, but to a less height than I ever observed before. No noise could be perceived. After continuing two or three minutes, the spout having first become gradually lighter coloured, either withdrew into the cloud, or became so transparent as not to be observed; but the water continued to be agitated for at least a minute afterwards. The weather was exceedingly sultry. The sky in most places was overcast with thick clouds, which frequently descended in squalls of rain. There was no thunder nor lightning that day. The wind at the ship was from the NE., but was only in very light airs. The Thermometer was at 84°. The distance of the spout might be about three miles, as we saw the water beyond the base.

The height of the cloud, from which it descended, might be about 25°; between it and the horizon, the sky was very black and thick.

Art. VI.—*On the Climate of Southern Africa, with an Abstract of a Meteorological Register kept at Graaf Reynet.* By R. Knox, M. D., M. W. S. Communicated by the Author.

I.—*General Geographical Situation of the Country to which the Meteorological Remarks and Tables apply.*

At the distance of about 135 miles from the Southern Ocean, in Lat. 32° 11′ S., and Long. 26° E., stands the village of Graaf Reynet, in one of the north eastern districts of the colony of the Cape. In this village, the Thermometrical Tables were kept; and with the exception of the Cape peninsula, and the southern maritime track, will be found very generally applicable to every part of the colony; or, more correctly speaking, to that portion of Southern Africa lying between Lat. 28° and 34° N., and Long. 18° and 28° E.

The *localities* of the village require, in order to secure accuracy, to be pointed out. Its population consists of about 1600 souls; it is situated on the banks of the Sunday River, (an inconsiderable stream,) on a level piece of *red clay soil*, or, as the natives call it, *Karroo*: Hills having an elevation of about 1500 feet, and composed of naked sandstone *strata*, shut in the village on its northern and western aspects; and these, no doubt, contribute somewhat in elevating the temperature of the air in the village above that of the surrounding country. To the south and south-east, an open desert country extends towards the ocean, as far as the eye can reach; and the commencement of the Great Karroo or Desert is about eighteen or twenty miles westward of the village. To the north, at no great distance, are the elevated *Snowy Mountains*, extending over a very considerable tract of country. The precise elevation of the site of the village has never been ascertained, but it may be estimated at about 1000 or 1200 feet above the level of the sea *.

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* The thermometer (which was of spirit) was carefully compared with a mercurial one, and found to agree with it. The morning observations were made between 6 and 7, the mid-day observations about 1, the night observations between 7 and 8.

TEMPERATURE,—Fahrenheit.										
	Morning.			Noon.			Night.			Monthly Mean.
	Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.	
1818,										
May,	52°.26	70°	38°	69°.64	82°	52°	55°.90	74°	42°	59°.27
June,	45	55	36	67	75	53	49.38	63	44	53.79
July,	45.42	60	34	68.39	79	54	51.80	66	41	55.20
Aug.	46.5	55	36	69.32	80	56	51.71	63	40	55.84
Sept.	52.96	68	34	68.83	88	62	57.8	68	45	59.86
Oct.	53.17	64	40	70.71	88	55	43.28	67	47	55.72
Nov.	58.86	72	48	80.16	95	65	64.86	77	58	67.96
Dec.	61.5	71	52	82.56	95	70	65.96	75	58	70.01
1819,										
Jan.	62.16	72	57	83.6	100	75	68.16	75	60	71.30
Feb.	61.0	75	55	79.14	95	58	68.28	78	58	69.46
March,	58.93	66	44	74.58	82	63	63.34	75	52	64.28
April,	55.62	71	42	73.75	85	53	61.54	75	45	63.63
Annual Mean,	54°.45	75°	34°	73°.97	100°	52°	58.°50	78°	40°	62°.19

General Annual Temperature, 62°.19. Fahrenheit.

Remark.—The Mean for each month was calculated by adding together the temperatures of each day, and dividing the sum by the number of days in the month.

The following table, shewing the state of the atmosphere as to pressure, was kept by the same very accurate observer, J. Ernst. I regret to say, that, from the appearance of the barometer employed, I should deem a confirmation of the correctness of these observations necessary, by means of a better instrument.

	Barometrical Pressure.			Number of Rainy days throughout the year.	
1818,	Mean.	Highest.	Lowest.	Days.	
May, -	27,69	28	27,38	5	
June, -	27,75	28,8	27,43	2	
July, -	27,75	28	27,50	0	
August,	27,68	28	27,36	4	Storm, 4 days.
September,	27,75	28	27,50	1	
October,	27,74	28	27,48	10	
November,	27,62	27,80	27,45	7	
December,	27,57	27,75	27,40	8	Storm, 2 days.
1819,					
January,	27,60	27,80	27,40	9	Storm, 4 days.
February,	27,62	27,80	27,45	20	Storm, 1 day.
March,	27,71	27,90	27,52	7	
April, -	27,32	27,49	27,15	3	
Inches,	27,68	An. Mean.		76	11

TABLE shewing the prevailing Winds throughout each Month of the Year.

Months *.	Direction of the Winds, and General Remarks.			
1818,			West.	
May, -	Northerly, 28 days.	Southerly, 3 days.	— —	East.
June, -	—— 23 ——	—— 2 ——	— —	2 days.
July, -	—— 14 ——	—— 5 ——	3 days.	1 ——
August,	—— 21 ——	—— 6 ——	1 ——	1 ——
September,	—— 8 ——	—— 18 ——	3 ——	1 ——
October,	—— 3 ——	—— 21 ——	5 ——	2 ——
November,	—— 5 ——	—— 23 ——	2 ——	
December,	—— 3 ——	—— 25 ——	2 ——	
1819,				
January,	—— ——	—— 27 ——	4 ——	
February,	—— 4 ——	—— 21 ——	1 ——	
March,	—— 9 ——	—— 18 ——		2 ——
April, -	—— 17 ——	—— 10 ——		2 ——
	135	179	21	11

It is not with any interested view of enhancing the value of these tables, that I shall here endeavour briefly to point out their superiority over others made in Southern Africa. Hitherto all Meteorological observations have been limited to Cape Town, or at least to the *Cape peninsula*, which, from its almost insular situation, its lofty mountains, deep bays, and proximity to the ocean, possesses a climate having little in common

* It is to be remarked, that the Northerly winds include the north-west winds, which may perhaps be considered as the quarter from which the winter winds chiefly blow; and under the head of Southerly winds are included the south-east winds, which blow during the summer.

The annual range of the barometer in the above table is 0,93; and the range or fluctuation of the barometer is greater in winter than in summer, in the ratio of 4,19 to 2,17; or the mean range of the six winter months is to those of summer as ,69 to ,36, confirming a fact long ago established by Mr Dalton with regard to the northern hemisphere. The connection betwixt the barometer and rain may be traced in the above table, a circumstance also first pointed out by the same ingenious author. During the dry and cold winter months of May, June, July, August, September, and April, the barometer is observed to have a much higher range than during the warm and rainy months of October, November, December, January, February and March; yet an inspection of several barometrical tables leads me to conjecture, that the changes in the barometer are more connected with the temperature of the atmosphere than with rain or humidity.

with the more inland tracts of Southern Africa *. Calamitous droughts, it must be allowed, not unfrequently extend over the whole colony, and affect even the Cape peninsula; but rains are very partial, deluging particular districts, whilst others are totally deprived of them. The boisterous south-east winds, which blow with such tempestuous violence at the Cape, are scarcely ever felt in the interior; a fact which, combined with many others, demonstrates the inaccuracy of those who would deduce from observations made in the Cape Town, any inferences or conclusions relative to the mean annual temperature, or the general meteorological state of Southern Africa. One of the advantages arising to mankind from the acquisition of meteorological knowledge, and that not the least, is the detection of the salubrity or unwholesomeness of the various climates which the surface of the globe presents; but as medical details, apparently, are incompatible with the plan of this Journal, I shall discuss these with as much brevity as possible.

Whatever conclusions may be drawn as to the nature of the climate of Southern Africa, (as far as is known to Europeans), from the preceding or other meteorological tables, *experience* shews, that it is one of the *healthiest* in the world.

Epidemics, those terrific scourges of mankind, are unknown; the dreadful fevers arising in marshy countries, from the combined effects of moisture, and a greatly increased or diminished temperature of the air, are never found in the colony of the Cape. During summer, the excessive heats occasionally excite bilious fevers in the young, chiefly of the male sex, and the hot N. and NW. winds give rise in some cases to nervousness and oppressed breathing. The same N. and NW. winds become in winter piercing cold, and occasion a considerable mortality amongst infants, by exciting inflammatory complaints of the chest; these winds are moreover extremely parching, and dry up the moisture of the face, lips, and inner membrane of the nostrils; their effects on the vegetable kingdom are similar. The medical man, and even the general reader, will readily ima-

* The thermometrical observations of a traveller, who is hourly altering his elevation above the sea, and degree of latitude, are of course unworthy the smallest attention.

gine, from a perusal of the thermometrical tables, that the colony of the Cape must be ill adapted for the abode of the consumptive. Experience, to which we can never too often recur, demonstrates the accuracy of this deduction. Pulmonary consumption is not an unfrequent disease with the colonists, and annually cuts off great numbers of the class of natives called *Hottentots.*

II.—*Temperature of the Northern Atlantic Ocean, and of the superincumbent Atmosphere between the Latitudes of* 50° 2′, *and* 20° 24′ N.

TEMPERATURE marked by Fahrenheit's Scale. The Thermometers were mercurial, and one of them extremely delicate.

Dates.	Lat. N.	Long. W.	At Noon.		At 6 A. M.		At 6 P. M.	
			Air.	Sea.	Air.	Sea.	Air.	Sea.
1817, April 3.	50°.2		53°	49°	50°	48°	50°	47°
4.	49.50		54	50	45	46	50	49
5.	48.56	7°.7	52	50	52	48	52	48
6.	46.50	8.55	57	53	48	48	50	50
7.	44.11	11.14	57	55	46	50	49	52
8.	41.45	13.40	60	56	52	52	54	53
9.	39.23	14.33	59	57	52	51	53	54
10.	36.32	14.45	61	60	55	55	58	56
11.	34.2	15.29	61	61	59	56	58	57
12.	32.37	17.5	64	60	58	58	60	59
13.	}	—	—	—	59	60	62	61
14.	} at	Funch	al,	—	—	61	64	62
15.	}	—	69	64	61	—	—	—
16.	30.51	18.9	71	64.5	61	61	64	64
17.	30.14	19.16	69	65	60	62	64	64
18.	29.30	19.48	73	66	63	64	66	63.5
19.	28.23	20.32	71	66	65	63	66	65
20.	28.4	21.45	72	67	65	64	67	65
21.	27	21.19	71	68	69	64	68	66
22.	25.20	20.52	71	68	67	66	70	66
23.	23.41	21.15	73	69	69	67	70	67
24.	21.56	23.12	73	70	70	67	70	68
25.	20.24	24.27	73	71		68	72	69

From the above table, and a few others which exist, may be seen the remarkable equability of temperature enjoyed, as well by the great ocean, as by the superincumbent atmosphere. This, which is neither disturbed by storms, nor changes of seasons, nor by the vicissitudes of day and night, has not been sufficiently insisted on by meteorological, and but ill understood by medical writers. Hence we find them attributing to various

occult qualities the healing powers of marine air in several diseases, and more particularly in pulmonary consumption. Either not understanding, or not believing in the extraordinary equability of temperature which prevails in the air over extensive oceans, they have ridiculously ascribed the effects arising from this alone to the "saline humidity of marine air; to its greater density and elasticity; and to its being more agitated by winds." Nearly all the facts which the Annals of Medicine contain, tend to prove, that, to the mildness and equability of marine air, is to be ascribed its extreme salubrity in consumptive diseases; and by reflecting on this fact, we may see the absurdity of directing consumptive patients to sail along a coast, or in an inland-sea, where the temperature of the marine air differs but little from that of the neighbouring continent or island. It is, for example, well known to Greenland whalers, and seafaring men trading to the North Seas, that the Baltic is often frozen, when the great ocean, ten degrees farther north, is open, and the weather mild. Seamen are made aware of the vicinity of land, by the sudden cooling of the air and of the sea; and this, indeed, is reckoned an almost infallible test of their approaching the coast.

The effects of the sun's declination on the temperature of the great ocean situated within the Tropics, or of its atmosphere, are inconsiderable. This is sufficiently proved by tables of the temperature, which have been kept by some individuals, and by the uniform weather experienced whilst crossing these fatal climates. Yet there would seem to exist a certain difference between the climate of the northern and southern hemispheres, even within the tropics. The very peculiar climate called by sailors the *Rains*, is found to exist only to the north of the Line, between the Equator and the 13th degree of north latitude. These *Rains* extend nearly across the ocean, in a belt, varying in breadth, but having generally about ten degrees of latitude. They are felt in every degree of longitude between 5° and 30° W., nor are they experienced more severely at any one point than at another. Formerly, when the art of navigation had not reached that perfection which it has now attained, vessels bound to the southern hemisphere were wont to make disastrous voyages, attributable often to delays of many weeks

whilst crossing this belt or zone. The calms which constantly prevail, are attended with alarming squalls, heavy gales, and almost continual rains. A sultry and intolerable suffocating heat, which at no season of the year is absent, occasions fevers among the crew, and gives a temporary shock to the strongest nerves. This is not to be ascribed altogether to the actual temperature of the air in this climate, but to its being combined with *moisture*, to which union may fairly be attributed the origin of most epidemic fevers. The meteorologist will readily imagine the direful effects likely to arise to the human frame, when the temperature of the air, and its humidity, are much increased beyond what happens at sea, between the latitudes of 15° N. and 15° S. But innumerable meteorological observations shew, that large continents, or extensive islands, possess a climate totally different from that of the great ocean, the temperature of the air being much increased during summer, and diminished in winter; and moreover, being liable to sudden alternations from hot to cold, and *vice versâ;* changes which never happen at sea. The atmosphere also over land, is apt in various situations to become surcharged with moisture, which, combined with great heat, is the undoubted cause of those fatal fevers known in various parts of the world, under a variety of names, by some supposed to originate in contagion, and by others in *marsh miasmata.* In temperate and cold climates, a humid atmosphere gives rise to intermittents or agues *.

When we examine the great zone comprised between 20° N. and 15° S. latitude, we find that nearly all those places which have been rendered famous by the destruction of European adventurers, are included in it. On the American continent,

* It cannot surely be necessary to point out to those accustomed to meteorological enquiries, that the atmosphere resting on the great ocean, by the equability of its temperature, and the uniformity of its qualities as to moisture, will, under very few circumstances, be found capable of exercising over the human frame the same dreadful powers as the inconstant air of a continent or large island, subject to endless variations, from the change of seasons, and even by the alternation of day and night. The doctrine of *marsh miasmata* may fairly be ascribed to an unwillingness in the human mind to admit as the sole cause of destructive epidemic fevers a phenomenon so simple as a change in the constitution of the atmosphere, regarding its temperature or moisture; and one, too, apparently so inadequate to the production of such dire effects. Those who cannot explain the origin of remittent and intermittent fevers, without having recourse to *marsh miasmata*, will find it difficult

may, as a specimen, be mentioned the ports of Vera Cruz, the Bay of Honduras, Darien, St Juan, St Lucie, Trinidad, the mouths of the Orinooco, Surinam, and Demarara. In Africa, Senegal, Goree, Sierra Leone, and Benin. In the east are Ceylon, Sumatra, Borneo, and Batavia. I shall conclude these remarks, already perhaps too long, by an observation on a very interesting migratory bird, the Swallow.

On the 21st November, in latitude 6° 4′ N., and longitude 20° 31′ W., we experienced those heavy squalls and rains, which, as has been already remarked, are uniformly met with in this climate. These storms are occasionally sublime, and worthy of a minute description. After the most perfect calm, heavy, dense, and gloomy clouds are seen collecting at every point of the horizon; they form themselves into vast arches, having their abutments in the ocean; suddenly at one point they blacken to an inky hue; the sails are furled; the crew stand in mute attention, each at his station, and every eye is directed towards that vast and hideous mass of clouds, which, resting on the surface of the deep, and reaching heaven with its top, advances upon the devoted vessel. Now, sweeping the ocean, it pours a deluge on the ship; the storm rages, and, by the terrific force of the blast, the masts seem ready to start from the decks. When these squalls happen at night, and are attended with much rain, a ball of meteoric fire is seen at the mast-head, tending to increase the horrors of the storm.

On the 21st, whilst beset on all sides by these squalls, a swallow suddenly appeared close to the ship. There was no known land nearer than 300 miles; the swallow was seen first during a calm, skimming round the vessel with great velocity and activity, and seemed to feed abundantly on the flies which hovered round the ship's sides. But during the squall which succeeded, its actions became those of self-preservation, and were admirably adapted to that purpose. As the rain poured in torrents, it beat down the swallow's head in spite of all its efforts, thus interrupting its flight round the vessel. When the bird perceived this taking place, it rose perpendicularly through the air and dense rain; fluttering moreover incessantly, and thus throwing

to account for the absence of agues in the district of *Lammer Muir*, (about twenty miles south of Edinburgh,) since the cutting down and destruction of the forests with which that country once abounded.

off the water from its wings. The amazing courage and strength displayed by this bird, in contending against the numerous storms with which we were assailed, during many hours, convinced me of its power to perform the longest migrations with comparative safety. The swallow remained with the vessel during two days, and sought shelter in the shrouds only at the approach of evening.

ART. VII.—*Observations on the Solar Eclipse of 7th September* 1820, *made at Gibraltar; with Remarks on the Temperature of the Water in Gibraltar Bay**. By MR ANDREW LIVINGSTONE.

As I have not observed in either *The Edinburgh Philosophical Journal*, or any other publication, a statement of any observation of the Solar Eclipse of 7th September last having been made at Gibraltar, I take the liberty of sending you the following, copied from my journal.

"SOLAR ECLIPSE, 7TH SEPTEMBER 1820.

"Ended, by my observation, at $3^h\ 20'\ 18''\ 14'''$ mean time, which, allowing $2'\ 12''\ 38'''$ equation of time, is equal to apparent time at Gibraltar, $3^h\ 22'\ 30''\ 52'''$.

"The observation of the end was made with an achromatic telescope of 48 inches focal distance.

"The time was found by Pennington's chronometer, N° 195. the rate of which was $2''$ daily gain. And the apparent time was ascertained by nine altitudes of the Sun, taken with Troughton's pillar-sectant, N° 888. and an artificial horizon made by Allan. The altitudes for the horary angle were worked in two sets, the difference between which amounted to $0''\ 13'''$, and the mean was assumed for the time stated above.

"The time was taken by Mr Robert Hardy, chronometer-maker, and the observation by myself."

The above is a literal copy from my journal; but it may be proper to add, that I unfortunately missed observing the commencement of the eclipse, in consequence of the Gibraltar Almanack having been so erroneously calculated, as to mislead me about $20'$ with respect to the beginning, and I unfortunately had trusted to it as having been calculated for the meridian of the place. The end of the eclipse I saw well; and what

* Communicated in a letter to Archibald Constable, Esq.

I remarked particularly was, that, for some seconds before it, I could perceive little or no difference in the appearance of the impression of the ☽ on the ☉'s limb, and that the eclipse seemed to end (if I may use the expression) as if the ☉ and ☽ had for a little adhered together, and then burst suddenly asunder. The telescope I used belonged to Mr Hardy; it was not on a stand, but was rested so as to enable me to observe with ease, and, I think, tolerable accuracy. I observed at the top of Mr Hardy's house, in Lat. 36° 9′ 13″ N. and nearly on the meridian of Europa Point.

The altitudes for the horary angle were taken at the King's Bastion, which cannot differ more than a second from the latitude of Mr Hardy's house.

I remark, that, in Number VI. of *The Edinburgh Philosophical Journal*, my remarks on the utility of the thermometer are inserted. I am happy to say that subsequent experience has confirmed their accuracy; and I have lately observed a remarkable difference in the temperature of the water in Gibraltar Bay, with easterly and westerly winds. The former raising the mercury, in Fahrenheit's thermometer, four or five degrees higher than the latter; which unquestionably must arise from the waters of the Mediterranean being warmer than those of the Atlantic, and from the pressure of the easterly winds, or Levanters, as they are called at Gibraltar, giving the waters of the Mediterranean a westerly tendency.

Mr Rumker * makes the latitude of Europa Point, at Gibraltar, ... 36° 5′ 15″

I make it by the sextant and artificial horizon, ... 36° 6′ 10″

Malaga Mole (Lighthouse) has been hitherto erroneously given; I made it by means of many meridian observations, exhibiting extremely accordant results, 36° 42′ 18″. The uncertainty arose from the discrepancy between former observations, caused by the exhalations from the river, which runs out into the sea almost on the line of the horizon, and which has caused most discordant results between observations taken by good observers, and with excellent instruments, when taken by the natural horizon.

LIVERPOOL, 19*th May* 1821.

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* Edin. Phil. Jour. vol. i. p. 322.

ART. VIII.—*Observations on Magnetic Attraction.* By S. H. CHRISTIE, Esq. In a Letter to Dr BREWSTER.

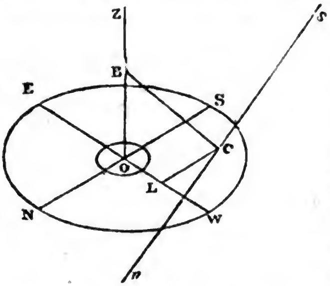
SIR,

IN compliance with your request, I transmit you an abstract of a paper of mine on Magnetic Attraction, read in May 1820, to the Cambridge Philosophical Society, and published in their Transactions, and in addition to this, I have applied the hypothesis there advanced to phenomena observed in different latitudes. In conclusion, I have adverted to the coincidence of my views of the subject, with the theory deduced by Ampere, from his judicious and elaborate experiments.

In that paper, I endeavoured to account for the phenomena arising from the action of masses of iron on magnetised needles, on an hypothesis different from that generally received. It appeared to me unnecessary to suppose, that any part of a mass of soft iron should possess the power of repulsion, and indeed that almost a necessary distinction between unpolarised and polarised iron was, that the one possessed the power of attraction alone, while the other possessed in addition that of repulsion. Several phenomena seemed to indicate that the iron did not act upon the needle in its horizontal position, but in the same manner as if the needle were inclined to the horizon, at an angle equal to the dip. From this view, it followed, that when the centre of a sphere of iron is in a plane passing through the centre of the needle, perpendicular to the line of the dip, the upper and lower branches of this imaginary needle being equally acted upon by the iron, the horizontal needle will not be affected by it; that when the centre of the sphere of iron is above this plane, the upper or south branch of the imaginary needle being more attracted than the lower, the south end of the horizontal needle will deviate towards the sphere; and that the contrary will take place when the centre of the sphere is below this plane. Finding that the directions, and also, as near as I could judge, the magnitudes of the deviations of the needle were such as might be expected on this supposition, I considered that this mode of action of the iron might be accounted for on the hypo-

thesis, that the needle was guided in its horizontal direction, by magnetic particles in a line passing through its centre, in the direction of the dip, and that the iron acted principally, if not wholly, on these particles, causing, by their deviation towards it, a corresponding deviation of the horizontal needle.

In the different experiments which I made, the apparatus consisted of a cast-iron ball 12.78 inches in diameter, suspended over the centre of a table, in the construction of which iron was carefully excluded. In the middle of the table a circular hole was cut, 13.25 inches in diameter, so that the ball could be let down below the plane of the table, or raised above it, by means of a system of pullies. After the table was rendered perfectly steady and horizontal, the magnetic meridian was accurately ascertained, and being drawn, the table was divided at every 10°, reckoning from the meridian, by lines drawn from the centre to the circumference. The compass being placed on one of the divisions, so that its north and south line coincided exactly with that division, and its centre was at the distance of 12 inches from the centre of the table, the ball was raised until it appeared to have no influence on the needle: it was then lowered, inch by inch, and the deviations at every inch carefully noted, until the ball had descended so far below the table as to cease influencing the needle. This was done with two compasses, at every 10° from the north to the west, and from the south to the east. NESW, represents the plane of the table, the centre of which is O. NOS is the magnetic meridian, and EOW at right angles to it, passing through the east and west points; C



is the centre of the magnetic needle, and sCn, in a vertical plane, parallel to SN, the direction of the dipping needle, in which I suppose magnetic particles to act upon the poles of the horizontal needle. CL, parallel to NS, is the line in which the needle points when influenced by the ball. OZ is a vertical line, from the centre of the table, in which the

centre of the ball is moved upwards or downwards; and CB is a line drawn perpendicular to sCn, and meeting OZ in B. According to the view of the subject which I have advanced, when the centre of the ball is *in* the point B, there should be *no* deviation of the horizontal needle; when the centre of the ball is *above* the point B, the *north* end of the needle should deviate *from* the ball; and when it is *below* B, the deviation of the *north* end should be *towards* the ball.

To ascertain how nearly the experiments coincided with these ideas, I computed, for every position of the compass, the height of the point B above the plane of the table. The following are the results compared with each other.

Angle from the Meridian.	Calculated height at which the deviation should = 0.	Observed height at which deviation = 0. North towards west.	Difference between the observed and calculated heights.	Observed height at which deviation = 0. South towards east.	Difference between the observed and calculated heights.
10°	± 4.185	— 3.95	— .235	+ 4.35	+ .165
20	± 3.993	— 3.90	— .093	+ 4.20	+ .207
30	± 3.680	— 3.70	+ .020	+ 3.65	+ .030
40	± 3.255	— 3.30	+ .045	+ 3.25	+ .005
50	± 2.732	— 2.80	+ .068	+ 2.90	+ .168
60	± 2.125	— 2.15	+ .025	+ 2.10	— .025
70	± 1.453	— 1.50	+ .047	+ 1.40	— .053
80	± 0.738	— 0.90	+ .162	+ 0.80	+ .062

I made similar observations, placing the needle at the several distances of 14, 16, and 18 inches from the centre of the table, for the values of φ 40° and 50°, as at these angles the changes in the deviation become very sensible. The following are the results obtained.

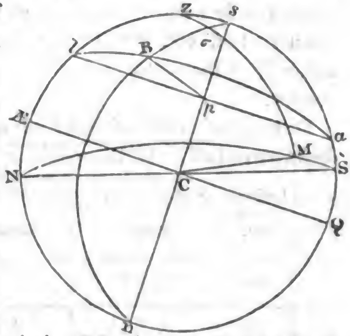
Angle from the Meridian.	Distance of needle from centre of table.	Calculated height at which deviation should = 0.	Observed height at which deviation = 0.	Difference between the observed and calculated heights.
40°	14	3.797	3.75	— .047
	16	4.340	4.33	— .010
	18	4.882	4.90	+ .018
50°	14	3.187	3.20	+ .013
	16	3.642	3.70	+ .058
	18	4.097	4.15	+ .053

In the observations made from the *south* towards the *east*, the deviations of the *north* end of the needle were first *easterly*, that is *from* the ball, in which direction they gradually increased as the ball descended, and attained a *maximum* ; they then decreased to zero, became westerly, attained a *maximum* in this direction, and then decreased until the needle resumed its original position. In the observations made from the north towards the west, the deviations were exactly in a contrary order. All these were precisely what I had anticipated.

Having ascertained that the quality of the deviations was such as would be the necessary consequence of my hypothesis, my next object was to discover whether their quantity was such as would fully confirm this hypothesis, or was altogether incompatible with it. As the precise deviation of the horizontal needle must depend on the law according to which the magnetic particles in the line *sCn* were affected by the ball, and on the manner in which these particles acted on the poles of the needle; and as I found there must necessarily, in the first instance, be almost insuperable difficulties in the determination of these laws, I endeavoured to find some further criterion of the correctness of the hypothesis, that should be independent of the nature of these laws.

If the ball acted alone on the particles in the line *s* C *n*, it was evident that being carried round that line, so that its perpendicular distance from any one point in it should always be the same, then these particles must always be influenced in the same manner towards the ball; and, consequently, a needle, in the si-

tuation s C n, ought to deviate by the same angle towards the ball, in the whole of its revolution round the line s C n. Hence it would follow, if the hypothesis were correct, that the angle of deviation of the horizontal needle, when referred to the angular deviation of the line s C n, should give the same angle during the whole revolution of the ball round the line s C n. Thus, let N′MS′ be in the plane of the table, N′CS′ being parallel to the meridian line; C the centre of the compass; s C n the direction of the dip; ÆQ a circle perpendicular to sCn, and passing through the centre of the needle; l B a any other circle perpendicular to the line s C n, and in which the ball is supposed to be carried round that line.



The circle ÆQ, that in which we have found the deviation to be nothing, being perpendicular to our magnetic axis, may be termed the magnetic equator; Æ l will then be the latitude of the ball, and B s Æ the complement of its longitude, reckoning from the intersection of ÆQ with the horizontal plane N′MS′. Suppose that S′CM, or the arc S′ M is the angular deviation of the horizontal needle, when the ball is at the point B; then the deviation of the particles, in the line s C n, will be in the plane of the circle s B n, and $s\,\sigma$ may be considered the measure of that deviation, as causing the deviation S′ M; $s\,\sigma$ ought, according to our theory, to be the same wherever the ball may be in the circle l B a.

I resolved, therefore, to observe the deviations of the horizontal needle, caused by the ball when in different situations in the circle l B a, and, reducing the arcs S′ M to arcs $s\,\sigma$, see how near they coincided with each other. As, however, the nature of the apparatus could not admit of the ball being carried round the compass, the compass was carried round the ball, in such a manner that the ball was always at the same perpendicular distance from the same point in the line s C n.

In the first set of experiments, I took CB 14 inches, and C p 6 inches, and having observed the deviations at every 10° of longitude, I found the mean value of $s\,\sigma$ computed from these

(exclusive of four observations which I had reason to suspect were incorrect,) to be 6° 46′; the greatest value 7° 6′; and the least 6° 33′. This coincidence was, as near as I could possibly expect, from the nature of the experiments.

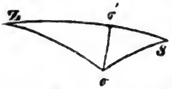
In three other sets of experiments, the compass was adjusted somewhat differently; and in these the deviations of the horizontal needle were observed at every 10° of longitude, for the latitudes 30°, 45°, 60°, having the ball at the distance of 18 inches from the centre of the needle. These gave the following results:

Distance of centre of ball from centre of needle = 18 inches, diameter of ball = 12.78, weight = 288 lbs.

Latitude of the ball.	Values of $s\,\sigma$, computed from the horizontal deviations.		
	Mean.	Greatest.	Least.
30°	3° 36′	3° 51′	3° 25′
45	3 55	4 00	3 47
60	3 18	3 25	3 15

The remarkably near agreement of the several values of $s\,\sigma$ for the respective latitudes, fully confirmed the views with which the experiments were undertaken, and proved clearly, that as the ball was carried round the magnetic axis s C n, the horizontal deviations were such as would arise from the deviations of the particles in the line s C n.

As a further test of the correctness of my hypothesis, I applied it to the deviations of the dipping-needle. According to the foregoing principles, $s\,\sigma$ being the deviation of the particles



in the line s C n, which is the direction of the dipping-needle, if $\sigma\,\sigma'$ be drawn perpendicular to the meridian, $s\,\sigma'$ would be the deviation of the dipping needle when it is placed in the plane of the meridian, since it can then only move in that plane, and $\sigma\,\sigma'$ would be the deviation of the same needle, when placed in a plane at right angles to the plane of the meridian: $\sigma\,\sigma'$ being observed, the angle σ' Z σ, or the horizontal deviation, might be computed from it.

The dipping-needle was placed due west, at the distance of 18 inches from the centre of the table, and the mean of the de-

viations, when its face was north and south, taken for different heights of the ball. A horizontal compass was likewise placed at the distance of 18 inches from the centre of the table, and having its centre at the same height as the centre of the dipping needle. The following are the results obtained:

Height of centre of ball above centres of needles.	Mean deviation of dipping needle.	Horizontal Needle.	
		Mean observed deviation.	Deviation computed from deviation of dipping needle.
10 inches.	2° 05	6° 10′	6° 13′
5 inches.	1 36	5 00	4 47
0	0 05¾	0 10	0 17

This agreement in the observed and computed horizontal deviations was the more striking, from the smallness of the arcs σ σ'. The several deviations of the dipping needle, and of the horizontal needle, in all positions, being then the necessary consequences of such an hypothesis, I concluded, that when a mass of iron is removed beyond a few inches from the ends of a magnetic needle, so that they are beyond the influence of any accidental magnetism in the iron, the deviation of the needle arises from the action of the iron on magnetic particles in a line, passing through the centre of the needle in the direction of the dip.

In the conclusion of the paper, I pointed out the application of this theory to the determination of the deviations of compasses on board of ships. I also hinted, that it might be applied to the changes which have taken place in the variation and dip of the needle, mentioning that the computations founded on it, which I had made, agreed to within less than half a degree with those observed in London, during a period of more than 200 years. I have since made similar computations for the changes in the variation at Paris, which give results equally near to the observations during the same period.

Having stated the hypothesis which I adopted, and the general results by which it is supported, I propose to apply the same principles to phenomena, which have been observed in different latitudes; and, for this purpose, I have selected those published by Mr Lecount, made with great care and perseverance at St

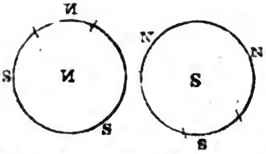
Helena, and during the voyage home, on board H. M. S. Conqueror, as offering results obtained under different dips of the needle.

The first experiments which he details, are some on long iron bars; and in these, in a great variety of positions of the bars, he marks the situations of the compass, where its respective ends appeared to be attracted by the bar, and also the points where the compass appeared not to be influenced, which he calls "neutral" points. These were made at the several dips of the needle, 12° S. 23° N. 61° N. As, with a little attention, it is immediately seen that, in all these, when the compass was at the "neutral" points, the centre of the bar was in the plane of the magnetic equator of the compass, and therefore, according to what I have stated, ought not to influence the horizontal needle, I shall not dwell on them, but proceed to some which were made with an iron ring in different positions.

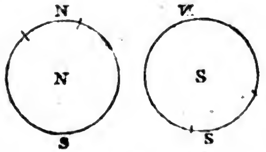
"The following experiments were made in latitude 32° N. longitude 38° W., with an iron ring 10.2 inches in diameter, and 5.5 inches thick, with the ring vertical; the letters on the ring shew which pole of the compass was attracted; and the letters in the centre of the ring shew which plane the compass was placed against.

"From vertical to horizontal southerly, very slight changes; but with an inclination of 45° top to the northward, south face attracted all round the north end of the needle, and the north face attracted the south end of the needle all round. Edges were nearly neutral.

E. & W.



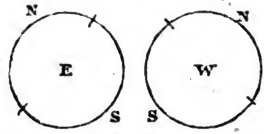
NE. & SW.



"Inclined 55° northward, north side attracted nearly all south, and south side nearly all north. Bottom faintly inclined to attract south *."

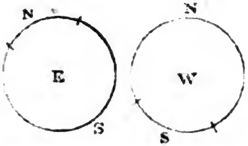
* The left hand figure has been altered, as in Mr Lecount's it is viewed in a contrary manner to the others.

N. & S.



"Inclined either way caused very little alteration."

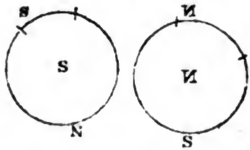
N. W. & S. E.



"Inclined 60° E. made east face nearly all south, and west face nearly all north."

"Compass placed at bottom of south face, had its south end attracted, but by inclining the ring 25° or 30° N., had its north end attracted, and at bottom of north face attracted south, with the ring at all southerly inclinations. In shifting from NW. and SE. to W. and E., note the west face of the ring becomes south."

W. E.



In order to point out the results which should here be obtained, according to our hypothesis, I conceive a sphere to be described about the centre of the needle (as in Fig. p. 293.), and this sphere to be cut by a small circle, whose diameter is equal to that about the centre of the ring of iron, which the compass in the experiments described: then if the centre of the ring be carried in the circumference of this circle, the planes of the ring and circle coinciding, the ring and compass will have the relative positions in the experiments. We must further observe, that the dip of the north end of the needle, where these observations were made, was about 65°, so that the magnetic equator of the needle would be inclined to the horizon at an angle of about 25°, rising from the north. In the first experiment, the small circle cuts the magnetic meridian and the horizon, at right angles, and is unequally divided by the magnetic equator. Let us suppose that the ring is to the south of the compass, as in the left hand figure. Then, when the centre of the ring is in the magnetic equator, the situation in which, according to our hypothesis, it will not affect the horizontal needle, the compass is opposite to a point above the centre of the ring. When the

centre of the ring passes below the magnetic equator, it then acts most strongly on the northern branch of our column of magnetic particles, and, in consequence, the north end of the needle ought to deviate towards the ring; and this should continue until the centre of the ring again intersects the equator. The centre of the ring now rising above the equator, the ring will act most strongly on the southern branch of our column, and, in consequence, the south end of the horizontal needle would deviate towards the ring during the remainder of the revolution. From this it is evident, that the points opposite to which the compass is, when the centre of the ring is in the magnetic equator of the needle, will divide the ring unequally. The upper, or that opposite to which the compass is when the north end of the needle deviates, being the smaller portion; so that the less portion of the ring at the top would appear, according to Mr Lecount's expression, to possess "north polarity," and the greater, at the bottom, "south polarity." The phenomena, when the ring is to the north of the compass, would take place in a similar manner, but in a reverse order. While the small circle, in which the centre of the ring moves, is inclined southerly towards a horizontal position, the only change that would, according to our hypothesis, take place in the "neutral" points in the ring, is, that they would more nearly bisect it; but when the circle is inclined northerly, at an angle of 45°, the centre of the ring, when it is to the south of the compass, would always be above the equator, so that the south end of the needle ought always to deviate towards it, though but slightly, when opposite the upper part of the ring: the reverse ought to take place when the ring is to the north of the compass; all these are precisely the effects observed by Mr Lecount, as stated above.

Let us now see what effect we should expect when the ring is vertical, and has a NE. and SW. direction. Here the small circle is still divided unequally by the equator; but the point of division on one side will be considerably higher than on the other, and when the ring is to the south of the needle, reasoning as in the last case, the point separating the northern from the southern deviation will be higher on the eastern, or in the figure the left hand side, than on the western. The contrary of this ought to take place, when the ring is to the north of the

compass. When the ring is NE. and SW., it will require a greater inclination than before of the circle to the north, to throw it above the equator; but an inclination of 55° will have this effect when the ring is to the south of the needle, so that then the deviation should be all of the south end of the needle towards the ring; and the contrary, when the circle is to the north of the compass; and these likewise correspond exactly with Mr Lecount's observations.

In the next experiment, with the ring N. and S., it is evident that the "neutral" points ought to be inclined as in the figure, and at the extremities of a diameter; their not being so, most probably arose from a slight partial magnetism in the ring, which it is extremely difficult to avoid; or perhaps from the ring not being accurately in the meridian, which was likely to be the case, as the experiments were made at sea, and it would be almost impossible to keep the ring in the same position exactly, with respect to the meridian, during the course of the experiment. The circle in which we suppose the centre of the ring to move being inclined either way, would cause little change in the points of intersection with the equator, and consequently in the "neutral" points, as observed by Mr Lecount.

From what has been said respecting the second and first experiments, it is evident that the positions of the points in the fourth and fifth, as we should determine them, would agree with those in the figures. In the fourth experiment, an inclination of 60° towards the east would throw the centre of the ring above our magnetic equator in the whole of its revolution about the compass, when the ring was to the west of the compass, and below it when to the east; so that the south end of the needle should always deviate towards the ring in the first case, and the north end in the second, as observed. In the fifth, when the ring was to the north of the compass, an inclination of 25° or 30° to the north would throw the circle below the magnetic equator, so that the north end of the compass would always deviate towards the ring; but with all southerly inclinations, the circle would always cut the equator; and when the ring was to the south of the compass, and the lower part opposite to it, the south end of the needle would still continue to deviate towards

the ring at all southerly inclinations, as observed to be the case by Mr Lecount. I have been under the necessity of stating the results that might be expected under the different circumstances, in a general manner, as we are not informed at what distance the compass was placed from the ring; but it is evident, that, if we knew this distance, we could determine accurately by the theory the different situations of the "neutral" points in all positions with the greatest facility, since it would be only necessary to determine the intersections of a given small circle with the magnetic equator.

In estimating the effects produced on the compasses on board ships by the masses of iron so variously distributed about them, I should refer their disturbing forces to a single point, which might be determined experimentally, then as the position of the ship's head changed, this point would revolve round the compass, and its position with regard to the magnetic equator of the needle, which would depend on the dip, the position of the head and the roll of the ship, would always point out the nature of the deviation, the quantity of which might in all cases be accurately computed from the proper data. Whoever compares this method with that which Mr Lecount was under the necessity of adopting, according to the theory of the changeable polarity of the iron, must admit, however attached they may be to that theory, that the one I have advanced possesses the most decided advantages in facility of application; and it is on these advantages, derived from theory, that I would more particularly insist.

I shall close my observations on the experiments of Mr Lecount, with a few on the instructions which he recommends for ascertaining the dip of the needle. This consists of an iron bar, which can be adjusted to any angle with the horizon, and is to be placed in the magnetic meridian; a compass is then to be carried along parallel to the bar, both above and below it, and the bar adjusted, so that the deviations above the bar are, for instance, all of the north end of the needle towards it, and those below of the south end, throughout the whole length; the inclination of the bar to the horizon will be the complement of the dip, of the same name as the elevated end of the bar, in the

present instance north*. Now, when the bar has this position, it will be parallel to the magnetic equator of the needle, and, therefore, wholly below that equator in one case, when, consequently, the dip end of the horizontal needle ought, according to the theory, to deviate towards it, and wholly above in the other, when the contrary end of the needle should deviate: when the compass is at the ends of the bar, this being in the equator, the needle would not be affected. Mr Lecount deduces the properties of this instrument from all the observations which he has so diligently and carefully made in different magnetic latitudes, and they are obviously the consequences of our theory; I therefore think we may conclude, from this and the other facts of his to which I have adverted, that the theory which has afforded me so ready an explanation of these phænomena, and those observed by myself in this latitude, will prove equally consistent with those that may be observed in different parts of the Globe. I have now only to add a few observations on the connection between this hypothesis and the theory of electric currents.

When I saw the first accounts of the electro-magnetic experiments of MM. Oersted and Ampere, which were not made till after my paper had been read, I did not consider that they would throw much light on the subject on which I had been engaged, as the connection between their experiments and mine appeared to be but remote. I however find, that the hypothesis which I had previously advanced, accords perfectly with the theory to which Ampere has been gradually led by his experiments. In these experiments, he appears to have been guided by the soundest views, and certainly displays the greatest ingenuity in the construction of his apparatus, and skill in its management. As one result of his experiments on the electric currents produced from the Voltaic pile, their actions on each other, on magnetised needles, and the action of the earth

* Should this instrument, or any other, be found to answer the purpose of determining accurately the dip of the needle in all cases on board a ship, it would supply the most essential datum for the computation of the deviation of the horizontal needle, in all positions of the ship, in all parts of the earth.

on these currents, he infers, that electric currents exist in the earth, in planes perpendicular to the axis of the dipping needle, and that the corresponding electric currents in the horizontal needle, perpendicular to its axis, are guided by these, so that the needle places itself in such a position, that the planes of these currents are as nearly parallel as the force of gravity, which acts on the needle, to retain it in a horizontal position, will admit; that is, that the axis of the horizontal needle will be in the plane perpendicular to the planes of the electric currents in the earth. If, now, the imaginary needle, or column of magnetic particles, which I have supposed to be influenced by the ball, and to guide the horizontal needle, consist of circular currents perpendicular to its axis, and the ball act principally on these, urging each of them to assume a position parallel to the tangent plane, at the nearest point of the sphere or perpendicular to the line joining the centres of the sphere and circular current, so that, by the joint action of the ball and the earth, they assume an intermediate position, then a needle freely suspended by its centre of gravity, would assume such a position, that the tendencies of the currents perpendicular to its axis, to become parallel to the terrestrial electric currents in the imaginary needle, should be equal on each side of the centre of suspension; and these terrestrial electric currents towards the end of the imaginary needle, nearest to the ball, being more affected than those at the other, that end of the suspended needle would be urged towards the ball, and, consequently, the terrestrial currents would also guide the corresponding end of the horizontal needle towards the ball, the respective deviations being estimated by the arcs $s\sigma$ S′ M (fig. p. 293), precisely in the manner which I have stated in the preceding abstract. The nature of this action of the ball on all the terrestrial electric currents, would not be unaptly represented by its action on one of them, that which passes through the centre of the needle, or, which is the same thing, on the equator of the dipping needle; and its deviation, arising from this action, or the deviation of its axis, which is equal to it, would represent the deviation of the imaginary needle towards the ball.

R. M. Academy, Woolwich, *May* 19. 1821. — S. W. Christie.

ART. IX.—*Account of an extraordinary appearance of the Sea, observed 31st July 1785, in a voyage from Johanna to Bombay,* Long. 61° 25′ E. Lat. 6° 32′ N. By FRANCIS BUCHANAN, M. D. Communicated by the Author.

ABOUT a quarter past seven P. M. the sea was observed to be remarkably white. The sky was every where clear, except around the horizon, where, for about 15°, it was covered with a dark haze, as is usual in such latitudes. The whiteness gradually increased till past eight. The sea then was as high coloured as milk, very much resembling the milky-way in the heavens; the luminous appearance of the sea resembling the brighter stars in that constellation. It continued in this situation till past midnight, and only disappeared as day-light advanced. The whiteness prevented us from being able to see either the break or the swell of the sea, although both were considerable, as we knew from the motion of the ship, and the noise. There was much light upon deck, as we could discern all the ropes much more distinctly than usual. We drew several buckets of water, in which, even when at rest, there appeared a great number of luminous bodies. The bulk of them did not appear to be more than $\frac{1}{4}$th of an inch in length, and nearly as much in breadth. Some, however, were $1\frac{1}{2}$ inch long, and of the same breadth as the others. These were seen to move in the same manner as a worm does in water. When taken up on the finger, they retained their shining faculty even when dry. When brought near to a candle, their light disappeared; but, by minute attention, an extremely fine white filament could be observed, and lifted upon the point of a pin. It was of an uniform shining colour and form, and about the thickness of a spider's thread. In a gallon of the water, there might be about 400 of these animals emitting light. The water itself, when in the bucket, had a natural appearance. The atmosphere was seemingly free from fog. The stars were bright, and there was no moon-light.

The night before, the same appearance was observed at ten P. M. It lasted only 20 minutes; but, as I was below, I did not hear of it till it was over. The chief mate and other officers

had observed the same appearance formerly in the same sea. They had several times, however, passed it, without observing any thing similar. No one on board had seen any thing of the kind in any other sea, except the gunner, who, in a voyage to China, had seen it off Java Head. The captain of the vessel in which he was, being alarmed, hove too immediately, sounded with 50 fathoms, but meeting with no ground, he proceeded on his voyage.

Observations.—The animalcules which occasion the usual luminous appearance on the sea, emit light only when strongly agitated, and, hence, appear chiefly close by the sides of the ship, or when any large fish passes swiftly, or when a bucket of water is drawn, and the water is suddenly poured out. In doing this, I have often observed that one of the animalcules stuck to my hand and shone for a little, but as my hand dried, the light disappeared; so that I never could bring the animal to a light so as to discover it by a magnifying glass. So much seems necessary to explain what I observed on the 31st of July 1785, when the luminous animals were not only larger and more numerous, but also emitted a stronger light than usual.

In the year 1805, in returning from St Helena to England, a little north from the Equinoctial line, and at no very great distance from the coast of Africa, I had an opportunity of seeing a still more splendid appearance of the luminous animalcules. Soon after dark in the evening, it being nearly calm, we saw numerous lights at a distance like the lamps of a great city. The lights gradually approached the frigate, and on reaching us, appeared to arise from a great many large fishes (albicores) sporting in the water, and agitating the animalcules so as to excite their luminous powers. The Marquis Wellesley, Sir George Cockburn, Sir Colin Campbell, and several other gentlemen of distinction, were witnesses of this splendid phenomenon, which was not, however, accompanied by the milky appearance.

FRANCIS HAMILTON.

Art. X.—*On the Action of Water on Magnesia and its Carbonate.* By Andrew Fyfe, M. D. Lecturer on Chemistry. Communicated by the Author.

Various statements have been given by different authors of the action of water on Magnesia. According to Dr Henry, water, when kept on this earth, does not dissolve more than a 2000th part of it. Kirwan states, that magnesia is soluble in about 7900 of water; while Dalton asserts, that it requires no less than 16,000 of this fluid for its solution. Sir Humphry Davy, on the contrary, states, that magnesia is scarcely soluble; and, according to Mr Brande, it is almost infusible and insoluble in water; while Dr Thomson considers it as quite insoluble in this fluid. The same diversity of opinion prevails with respect to the action between water and carbonate of magnesia. Thus, according to Mr Brande, it is a white, insipid, insoluble substance; while Dr Murray asserts that water takes up about a 2000th part of it.

Several years ago, when I first became acquainted with the fact stated by Dalton, that lime is more soluble in cold than in boiling water, it occurred to me, that magnesia might be acted on in a similar way by this fluid. By making solutions of the earth in cold and in boiling water, I found that the former required a larger quantity of diluted acid for neutralisation than the latter, using litmus paper as a test of the point of saturation. Accordingly, I concluded, that magnesia in its action with this substance was similar to lime, being more soluble in at its natural than at its boiling temperature. I did not, however, ascertain the quantities of the earth dissolved by water in these different states.

Since reading the paper of Mr Phillips on the solubility and crystallisation of lime, my attention has been again drawn to this subject. The experiments which I have performed, have enabled me not only to confirm the conclusion which I had previously made, but also to ascertain, I think, with precision, the quantity of magnesia dissolved by water, at a natural and at a boiling heat. The magnesia which I employed in the following experiments, was prepared by precipitating it from its sulphate, by means of an alkaline subcarbonate, and exposing it to

a red heat for some time, till the whole of the carbonic acid was expelled, having previously washed it, till the fluid which passed through the filter did not become turbid on the addition of nitrate of baryta; shewing that there was not an excess either of the sulphate of the earth, or of the carbonate of the alkali.

As the quantity of magnesia taken up by water is but small, I thought that the best method of throwing it down from its solution, would be by the addition of ammonia and phosphoric acid, so as to procure phosphate of magnesia and ammonia, which, after being subjected to a high temperature, gives out its alkali, and phosphate of magnesia is left, which is stated to contain, in a 100 parts, 40 of earth.

Exp. 1. Water at the temperature of 60° was kept on magnesia for several hours, and the fluid was then filtered. To twelve ounces of this, (5760 grains,) carbonate of ammonia, and then phosphate of soda, were added, and the precipitate thrown down was washed, till the fluid which passed through was not altered by nitrate of baryta, indicating that the whole of the alkaline salts was removed. After exposure to a red heat, it weighed 2.8 grains.

Exp. 2. Water was boiled on magnesia for about half an hour, and the solution was then filtered as quickly as possible, pouring but a small quantity on the filter, and keeping the remainder boiling during the filtration. From 5760 grains of this, after it had become cold, the magnesia was thrown down, as in the former experiment, and the precipitate was washed and treated in the same way, after which it weighed 0.4 of a grain.

Phosphate of magnesia and ammonia, as has been already stated, contains, after being heated to redness, 40 of earth in 100 parts. 2.8 of the precipitate, therefore, are equal to 1.12, which is the quantity of magnesia dissolved by 5760 of temperate water,

and as 1.12 : 5760 : : 1 : 5142.

Magnesia, then, is soluble in 5142 of water at a natural temperature.

Again, as 100 : 40 : : 0.4 : 0.16,

the proportion of magnesia held in solution by the boiling-water,

and as 0.16 : 5760 : : 1 : 36000.

Magnesia, therefore, requires 36000 of water at 212 for its solution.

To prove still farther that magnesia is more soluble in cold than in warm water, six ounces of its solution, made at a natural temperature, were heated very gradually in a long-necked flask, so as to prevent as much as possible the evaporation of the fluid. During the application of the heat, the liquid became slightly turbid; the moment, however, that it began to boil, a flocculent matter was precipitated, which, after being well washed, was dissolved by muriatic acid; and, from its solution, on the addition of carbonate of ammonia and phosphate of soda, a white precipitate was thrown down. During the heating, the fluid lost only 160 grains by evaporation, and afforded phosphate of magnesia and ammonia, on the addition of the alkaline salts.

These different experiments then prove satisfactorily the remarkable fact that magnesia is much more soluble in cold than in warm water. The same I have found is also the case with the carbonate of this earth. The carbonate of magnesia employed in the following experiments, was prepared in the usual way, washing it after its precipitation, till the whole of the substances in solution was removed.

Exp. 1. The powder thrown down by the addition of carbonate of ammonia and phosphate of soda to 5760 grains of a cold solution of carbonate of magnesia, was treated in the same way as that from the solution of the pure earth, after which it weighed 2.5 grains, which are equivalent to 1.0 of magnesia.

Exp. 2. 5760 of a warm solution of the carbonate, prepared in the same way as that of the pure earth, yielded, when cold, 0.7 of the magnesian phosphate, which are equivalent to 0.28 of magnesia.

The carbonate of magnesia which I employed in these experiments, lost by exposure to a strong heat 56.75 *per cent.*, leaving 43.25 for the magnesia. If this be the constitution of carbonate of magnesia, 1 of pure earth is equivalent to 2.31, and 0.28 to 0.64 of carbonate;

and, as 2.31 : 5760 : : 1 : 2493.

Again, as 0.64 : 5760 : : 1 : 9000;

so that carbonate of magnesia is soluble in 2493 of cold water,

while it requires 9000 of the fluid at a boiling heat for its solution. Other statements have been given of the composition of carbonate of magnesia, which will, of course, make the quantity of this substance dissolved by water to be different. The above experiments, however, prove, that it is soluble in this fluid when cold, and when warm, in the ratio of 2.31 to 0.64.

The more sparing solubility of carbonate of magnesia in warm than in cold water, was also proved, by heating gradually six ounces of its solution made at a natural heat, during which the fluid became very slightly turbid. At the instant that it began to boil, a minute quantity of a flocculent matter appeared, which, when dissolved in muriatic acid, became turbid, on the addition of carbonate of ammonia and phosphate of soda. During the heating, the fluid lost 190 grains by evaporation, and yielded ammoniaco-magnesian phosphate, when the alkaline salts were added.

In the paper of Mr Phillips above alluded to, it is supposed that the crystallization of lime occasioned by the heat, is the cause of this substance being less soluble in warm than in cold water. In the case of magnesia and its carbonate, I do not know if the same cause can be assigned for the difference in the solubility of these substances in water at different temperatures, as both of them are separated from the fluid during the heating, in the form of a light flocculent matter, which floats in the liquid,—an appearance very different from that presented by lime; this earth, in the experiments which I have performed, being deposited on the sides of the vessel, to which it adhered with considerable force.

I may here remark, that I have reason to believe, that other bodies are also more soluble in cold than in warm water. The experiments, however, which I have performed, are not sufficiently conclusive, to warrant my making at present any definite remarks on the subject.

Edinburgh, *July* 4. 1821.

Art. XI.—*Narrative of a Voyage to Davis' Straits in* 1820. By Mr William Jameson, Surgeon. Communicated by the Author *.

On the afternoon of Wednesday the 9th March, we sailed down the Humber in the ship John of Hull, a whaler bound to Davis' Straits. Our crew were thirty-three in number, which, with sixteen to be engaged at the Orkneys, was to complete our compliment. We accordingly shaped our course for these Islands; and, after a passage of fifty-six hours only, anchored in Stromness Roads. Here were fourteen whalers detained by a contrary wind, and about twenty besides moored within the harbour, which, being more sheltered, and affording a better anchorage, is generally preferred; and, indeed, would be invariably resorted to, were it not for the difficulty of getting out when the wind blows from the southward,—a disadvantage of too trivial a nature to make Stromness Roads the more desirable situation. There, however, we remained for twelve days, being occasionally obliged, from bad weather, to let go both anchors. On the 22d, having the wind from SS. W., we sailed through Hoy Sound, in company with nineteen sail of ships on the same trade.

The weather we experienced during our passage across the Northern Ocean was very tempestuous, in so much so, that we were frequently obliged to call the assistance of the whole ships company to take in the sails, and get every thing properly secured. On the 5th April, in particular, we experienced a most tremendous gale, accompanied with showers of sleet from the northward, which continued to blow for twenty-four hours with such violence, that we could carry no sail. At length, after many short alternations of good and bad weather, we made the Cape Ice on the 16th April, in Lat. 58° 25′, and Long. 47° 10′ W., having the wind from SE. On the same evening we laid the ship to, lest, by running too far among the ice, we should be afterwards unable to extricate ourselves. Next morning we had the wind from NW., with a very high sea, which, raising the floating ice to the same elevation, had a very threatening appearance.

* Read before the Wernerian Natural History Society.

Holding a NE. course, we, in Lat. 50° 4′, descried Cape Farewell, distant from us about twenty-five miles. It is very high and abrupt, and faced with numerous islands of the same general appearance.

On the 24th, having the wind from the NE., we reached across towards the opposite land; and, on the 26th, in Long. 58° 30′, came up to that pack which stretches along the west shore of Davis' Straits, usually termed the South-West Ice. Having sailed along the edge of this "Pack," from Lat. 62° to Lat. 63° 20′, without seeing any whale fish, and having spoke a ship who had met with no better encouragement, we, on the 30th instant, shaped our course for the northward, intending to go up the Straits.

The SW. ice affords but few objects to engage the attention of the naturalist. Whales were formerly very numerous, and of a size much superior to those met with farther north. From some unaccountable cause, however, they are now become comparatively rare, and but few ships choose to remain at the SW. ice during the fishing season. Seals are sometimes seen upon the floating ice, and, when practicable, are taken by the whalers, for the sake of their oil and skins. The birds were not numerous. Besides the Fulmar (*Procellaria glacialis*), and the Kittiwake (*Larus tridactylus*), which, however, we observed during almost the whole passage, the Glaucous Gull (*Larus glaucus*) and the Snow bird, (*Larus candidus* or *eburneus*), were now, for the first time, seen. Marrots (*Colymbus troile*), seem to be more plentiful here than in the higher latitudes.

In pursuance of our intention to go up the Straits, we steered an easterly course, and on the 2d May, in Lat. 65° 54′, we again came in sight of the mainland. It consists of a range of very high mountains grouped together, the summits of most of which are conical and pointed, while others are nearly perpendicular and terminating in rugged cliffs. For about a degree farther north, the coast presents nearly the same aspect. At Riskol in Lat. 68°, where we arrived on the 6th, it is much less mountainous and abrupt.

The sea about Riskol, at the commencement of the fishing seasons, is often much frequented by whales and morses. The former, when the ice begins to disappear, quit Riskol and re-

pair to the higher latitudes, while the latter remain on the rocks and islands in the vicinity of the mainland. At present, we saw nothing to induce us to stop here.

About 20 miles off Riskol, is a reef of sunken rocks, on which numerous icebergs are stranded. Holding an intermediate course, we fell in with North Bay Islands, which are, I believe, at present uninhabited. A little farther to the northward, is a wide inlet of the sea, named South-East Bay, at the entrance of which is Wester Islands, on which there is a factory of Esquimaux, placed there by the Danes for the sake of the whale-fishery. In the afternoon we were visited by the Governor, a native of Denmark, who spoke the English language with tolerable facility. He informed us that he had seen but few whales, owing, as he supposed, to the openness of the season, the preceding winter having been unusually mild. Whales, he said, are but rarely seen here during the summer (*i. e.* from June to August), when it is supposed they migrate to the higher latitudes, but in winter the adjacent seas are much frequented by them. Owing, however, to the shortness of the day, during the latter season, whale-fishing cannot be prosecuted with the same success as in April and May, which, on the whole, he considered to be the season best suited for that employment.

About 20 miles to the NE. of Wester Islands, is another group named Whale Islands, where we arrived the day following. Here is also a factory of Esquimaux, with a Governor, who, like his colleague at Wester Islands, is appointed to superintend the whale-fishery. Both are annually visited by a Danish vessel, which, in return for oil, furs, &c., supplies them with European commodities.

There are other small islands situated farther in the bay, which, about ten or twelve years ago, were regularly visited by the whalers, on account of the number of whales which frequented their shores. The ships, on their arrival in this country, were usually anchored in the harbours of Levely, or Whale Islands, from whence boats were dispatched, containing harpoons and other apparatus for taking these animals; and so numuerous were they, that, for several years in succession, the ships returned to their respective ports with a full cargo of oil and whalebone. Of late years, however, the whales seem to

have deserted their accustomed haunts, so that the ships employed in the fishery seldom enter the bay.

I should have been happy to have acquired some knowledge of the natural history of the islands in South-East Bay, but having had no opportunity of landing, I was obliged to content myself with a transient view of them. In height, they scarcely exceed 300 feet, their surfaces being uneven and rocky. On the contrary, the large island of Disko, which forms the northern boundary of the bay, is characterised by features very different. It is supposed to be the highest land in Greenland, but is chiefly remarkable for the boldness and regularity of its shores. The south-west coast in particular, is one continued precipice of many hundred feet of perpendicular height, from the summit of which a ridge of mountains ascends by a rapid acclivity, to a very considerable elevation. To give some idea of the height of this land, I shall only mention the fact of its being visible in the horizon at the distance of 80 miles.

Few species of birds were at this time to be seen. Eider ducks (*Anas mollissima*) were very abundant. Common and black guillemots (*Colymbus troile* and *grylle*) were equally plentiful. A few ravens (*Corvus corax*) were also seen flying about.

Having seen nothing to encourage us to stop in the bay, we plied to the westward, among large flat pieces of ice or floes, which, in the crevices formed by the aggregation of the smaller upon the larger fragments, exhibited the most beautiful azure-blue tints of colour. On the 11th, we arrived at the edge of the West Pack.

The quantity of floating ice on the west shore of Davis' Straits is so considerable, as to present an almost insurmountable obstacle towards approaching the land in that direction. This ice, which has from time immemorial occupied nearly the same situation, is termed the West Pack.

At the West Pack we saw several whales, but were not so fortunate as to "get fast" to any of them; although we had boats plying about in different places. Those animals named Beluga's, or white whales, (*Delphinus leucas*), were here particularly numerous. There are generally four or five of them together, describing in their movements (which are simultaneous) a semicircle or crescent above the surface of the water.

They are seldom or never taken, although it is said they yield a considerable quantity of very pure oil.

Here were a great many Little Auks, *(Alca alle)*. They live together in large flocks, feeding on shrimps, and fly very swiftly along the surface of the water, keeping always near the ice. The feet are placed far behind the centre of gravity, which enables them to swim and dive with great rapidity.

At the edge of the west ice we remained for a few days, without seeing any thing remarkable. On the 15th we killed a whale; and having continued for some days longer about the same latitude (68°), without a prospect of farther success, we made the best of our way to the northward. On the 25th we were in Lat. 70° 6', off the north end of Disko Island. About twenty miles to the NE. we could plainly discern Hare Island; but a cross bar of ice prevented us from penetrating farther in that direction.

It frequently happens that the summer is pretty far spent before a passage can be effected to the northward of Hare Island. This difficulty is occasioned by a range of icebergs, extending across the Straits, which, opposing different points of resistance to the floes, holds them for a long time in the situation in which they were originally formed. These floes or ice-fields, which are of annual formation, will, for a longer or shorter time, withstand the action of the waves, in proportion to their thickness and solidity, which will depend upon the mildness or severity of the preceding winter. The numerous icebergs which are permanent, are here rendered stationary, plainly indicating a less considerable depth of water, more especially as they are so arranged that the direction of the ground on which they are stranded can be easily traced.

Our progress to the northward being thus obstructed, we removed two degrees to the southward, in hopes of falling in with whales; but nothing remarkable having occurred, we made a second attempt to get to the northward, which proving as ineffectual as the former, we again returned to the southward. At the West Ice, abreast of Disko Bay, in Lat. 68° 38', we saw many whales, three of which fell to our share. On one of them was found a great number of crustaceous insects, adhering to the skin by their hooked claws.

On the 15th, we bore away to the northward, with a determination to await the breaking up of the ice, should a passage be still impervious. On the 18th, we passed close by the north side of Hare Island, without meeting with any obstacle,—a circumstance much to the satisfaction of every one on board, except myself, who would have been very well pleased had we been detained here for a few days. I had, till now, cherished the hope of acquiring some additional knowledge of the natural history of this island, or at least of collecting specimens of those plants I had before observed; but now that we have got to the northward, it is doubtful whether I shall have an opportunity of landing upon any part of the Greenland coast, or adjacent islands.

Nothing occurred to stop our course to the northward till abreast of the Women Islands, in about Lat. 73°. Here were several very large floes, which we were apprehensive would detain us for some time. However, by dint of towing and warping among them, we soon got into open water, and pursued our course to the northward.

With regard to the appearance of the coast, I may observe, that betwixt Lat. 71° and 73°, it is less high, and of a more uniform appearance, than any where to the southward. Beyond this, in Lat. 73° 40′, as seen from the ship, it seems to be entirely composed of a red coloured rock, broken in many places, into precipices of a considerable height. The tops of the mountains are, besides, more rounded than to the southward. Of the latter description there is a remarkably high mountain, situated in about Lat. 73° 50′, which being perfectly conical, with a rounded summit, has been hence termed Sugar Loaf Hill. More interiorly the valleys are completely filled with snow and ice, presenting to the eye an almost uninterrupted surface, on which no trace of land can be observed.

In Lat. 74°, and about five miles from the mainland, are three small flat islands, the haunt of myriads of sea fowl. Of these the various species of duck being the most abundant, they have been hence termed Duck Islands. There the crews of the different ships often supply themselves with eggs, which, at this season, may be collected in great quantities. On the 26th June, being becalmed at the distance of about a mile from one

of the islands, we resolved to proceed to the shore to collect as many eggs as we could find. A boat being accordingly got ready, we rowed towards one of the islands. On a near approach, we could see numerous flocks of ducks flying about in different directions. They were all of that species of duck named Eider Duck (*Anas mollissima*). The spot on which we landed was nearly level; and, being wet and spongy, was completely overrun with moss, to the exclusion of almost every other vegetable. The various species of *Hypnum* and *Polytrichum* were the most abundant, but none of them were in fructification. On an eminence on the west side of the island, I observed several plants, two of which only were in flower, viz. a *Potentilla*, with *ternate* leaves, hairy on both sides; calyx, with ten nearly equal segments; and a flower of the size and colour of our *Potentilla verna*. The other was a species of *Salix*. Besides these, there were *Andromeda tetragona*, *Cerastium latifolium*, *Silene acaulis*, *Stellaria humifusa*, *Papaver nudicaule*, a *Festuca*, probably *F. vivipara*, *Salix herbacea*, and a *Carex*, perhaps *C. rigida*. These, with two or three others, (whose names I could not ascertain), I collected for the Edinburgh Botanic Garden. The more common species of Lichens were *Cetraria islandica*, and *nivalis*, and various species of *Gyrophera* encrusting the rocks.

Of the minerals, the island affords but two species: the one which forms the top is of a more crystallised appearance; the other, a greyish coloured rock, descends in oblique strata to the shore.

Among the tufts of carex and other herbage, and generally in a sheltered situation, a few nests were observed. They all belonged to the Eider Duck, and were copiously lined with the down of that bird. Few eggs were found in them, they having been already robbed by the crews of some of the other ships. In a precipice by the sea-shore were several nests of black guillemots (*Colymbus grylle*). This bird nestles in holes deep in the rock, and lays but a single egg, large for the size of the bird, of a greyish colour, with dark brown spots. The glaucous gull (*Larus glaucus*) may perhaps breed here, at least a pair or two were seen flying about the island.

Upon the whole, the productions of the island are but few and scanty, when compared with those of the land three or four de-

grees to the southward. The species of phænogamous plants do not exceed twelve in number, and no land animal, properly so called, could be seen; not even an insect, although the sun shone with great effect. Perhaps, however, a more leisurely investigation may discover more species which, in the very cursory view I enjoyed, might remain unobserved. I missed many fine plants, which, in my former voyage, I gathered on Hare Island, and the opposite continent.

A breeze having sprung up, we were summoned on board before we could make a circuit of the island, which, however, we suppose to be about three miles in circumference. Although the coast is low, yet the water deepens so suddenly, that at the distance of two or three yards from the shore no bottom could be seen.

Having got on board, we made sail to the northward in company with fifteen ships. Ahead of us were two or three very large floes, which I imagined would have effectually barred all farther passage into the more northern regions. Resolved, however, to surmount every obstacle, rather than relinquish our design, we entered a stream or "*lane*" of water, about fifty yards in breadth, formed by the recession of two large floes, the edges of which ran parallel to a considerable distance. To accelerate our progress, all our people were ordered to go upon the ice, and pull the ship forward by the tow-rope. In the course of a few hours we had gained about five miles, when we were obliged to leave off towing, the two floes having approximated so closely, that it was thought unsafe to venture farther. It was here (Lat. 74° 30′), on the 29th instant, that we witnessed the destruction of a Hull ship, named the Brothers, while attempting to pass betwixt two floes, which were in the act of coming together. That ship had advanced ten or twelve yards only, when she was caught by the ice closing on each side of her. The united efforts of the crews of several other ships, to remove her from her dangerous situation, proved quite unavailing. The water rushed in, and continued to increase, notwithstanding that the pumps were incessantly at work. In the course of three hours, she was reduced to the state of a total wreck.

Our situation was by no means safe; for we were inclosed in such a manner by the ice, that a passage in any direction was quite impracticable; and had the wind blown with violence, (which rarely happens where there is much ice), our situation might have been very precarious. After having spent a few days with much anxiety, we were fortunately relieved from this embarrassment by the separation of the ice, of which we gladly availed ourselves to get into open water.

All apprehension of shipwreck having vanished, I return with pleasure to the contemplation of those various animated productions with which the Arctic seas are so plentifully furnished. In Lat. 75°, we met with a "run" of Sea Unicorns, (*Monodon monoceros*). They are gregarious, moving slowly along the surface by an undulating motion. The skin is smooth and soft, like that of the whale, but of a white colour, intermixed with black, very much resembling some variety of marble. They are very quick sighted, and, therefore, with difficulty taken. One which we killed by the stroke of a harpoon, measured about 10 feet. The twisted horn or tooth which projected from the extremity of the upper jaw, measured 5 feet.

Here the water teemed with mollusca of different kinds, said to be the natural food of whales and other cetaceæ. The more numerous was a species of Clio, about an inch in length, moving horizontally through the water by means of two fins of a conical shape, which it throws from side to side. Equally abundant was another small roundish black coloured insect, about the size of a pea. It is inclosed in a remarkably thin shell, and turns by means of two fins, which are protruded from its orifice. A small medusa was likewise very plentiful. When taken in the hand, being of a very soft gelatinous texture, it immediately lost a considerable portion of its substance; yet still retained its original form and vitality. It is of an octagonal form, and moves through the water by a tremulous motion, observable only at the angles which are ciliated, exhibiting at the latter part the most brilliant colours.

I do not recollect of having any where seen so many of those birds named Little Auks (*Alca alle*), as among the ice betwixt the latitudes of 74° and 76°. The water in many places, for a considerable space, was literally covered by them; and occasion-

ally they might be seen flying past the ship in flocks innumerable. I have before observed, that this bird seldom leaves the ice. The quantity of broken up floes floating about, will, perhaps, account for these birds being seen in such numbers. The other birds were the same with those which occur more to the southward. I should, however, mention one species which I do not recollect of having before seen. It is a species of Tringa, with pinnated webbed feet, like the red Phalarope (*Tringa hyperborea*), but differs from this species not only in colour but in several more important distinctions.

Having sailed along the east coast to about Lat. 76° 10′ without seeing any whales, we stood to the westward; and having sailed for about 250 miles in this latter direction, we came in sight of the west coast. Its appearance is different from that of the east land, being much more low, but rising gradually in the back ground into mountains of a considerable height. There are here several extensive bays and sounds, the most considerable of which is Lancaster Sound, in about Lat. 74° 30′. We entered it on the 1st of August, but having proceeded up for fifteen miles only, we could draw no inference respecting the possibility of a NW. Passage, nor did we hear any thing of the Discovery Ships. We observed the current to run invariably outwards, at the rate of about three one-half knots. The land on both sides rises very high, and is covered with an immense body of snow and ice. The shores are flat, and apparently worn smooth by the action of the water poured down from the higher land. The animals on the coast were bears and walrusses; the former very numerous, which had been probably allured by the number of whales which might occasionally be seen close to the land. There were other ships which penetrated much farther into the Sound than we did, and the acounts they bring of the possibilities of a passage by this Sound are, on the whole, favourable.

On the 12th August we returned to the east land; and having taken in a supply of water from an iceberg, we made the best of our way down the Straits. On the 3d September we doubled Cape Farewell, and, on the 23d, arrived at Hull, with twelve fish.

ART. XII.—*Memoir of the life of* MARTIN HENRY KLAPROTH *. By E. G. FISCHER.

MARTIN HENRY KLAPROTH, who was born at Wernigerode on the 1st of December 1743, and died at Berlin on the 1st of January 1817, is a remarkable instance of the extent to which a powerful mind may deliver itself, by a calm, but conscientious and persevering assiduity, from a fate which seemed to have doomed it to mediocrity or insignificance. His father, a citizen of Wernigerode, had the misfortune to lose his whole goods by a great fire, on the 30th of June 1751, so that he was able to do little or nothing for the education of his children. The subject of this memoir was the second of three brothers, of whom the eldest, a respectable clergyman, died many years ago at Plauen on the Havel,—the youngest, who was Private Secretary at War, and Keeper of the Archives of the Cabinet, died a few years ago at Berlin. Klaproth, like his two brothers, obtained such meagre instructions, in the Latin language, as the school of Wernigerode afforded, and was obliged, like them, also to procure his small school fees, by singing as one of the church choir. But the very circumstance which the wisdom of Providence made the beginning of his future distinguished course in life, seemed likely at the time of its occurrence to have placed him in a sphere inferior to that of his brother. It was his first intention, as it was also that of his elder brother, to have studied theology, but an unmerited hard treatment which he met with at school, so disinclined him to study, that he determined, in his 16th year, to learn the trade of an Apothecary. Five years which he was forced to spend as an apprentice, and two which he passed as an assistant, in the public laboratory at Quedlinburg, do not seem to have furnished the best education for a great chemist; for they placed him out of the reach of scientific study, and instead of that, secured nothing for him but a certain mechanical adroitness in the most common pharmaceutical preparations. In a paper which was found

* Read at the Public Sitting of the Royal Academy of Sciences at Berlin, on the 3d of July 1819.

among those that he has left behind him, he thus expresses himself: "I cannot boast of the instruction which I have received from my teachers. On the contrary, I was obliged to content myself with such information as I could gain, in those times, from the mechanical operations of my elder companions, and with the perusal of a few old Apothecary books, for the study of which, too, I had but little leisure."

He always regarded, as the epoch of his scientific instruction, the time when he first entered the public laboratory at Hanover, in which he spent two years, namely, from Easter 1766 till the same time in 1768. It was there that he first met with some chemical works of merit, especially those of Spielman and Cartheuser, in which a higher scientific spirit already breathed.

The love of science thus awakened, naturally aimed at a more complete developement. He was anxious to go to Berlin, of which he had formed a high idea from the chemical works of Pott, Henkel, Rose the elder, and Markgraf. An opportunity presented itself, and, about Easter 1768, he was placed as assistant in the laboratory of Wendland, at the sign of the Golden Angel, in the Street of the Moors. Here he employed all the leisure which a conscientious discharge of the duties of his station left him, in completing his own scientific education. And as he judged very correctly, that a profounder acquaintance with the ancient languages, than he had been able to bring with him from the Latin school at Wernigerode, was indispensable for a complete scientific education, he applied himself with great zeal to the study of the Greek and Latin languages, and had the good fortune to enjoy in this study, the assistance of a worthy and learned Preacher and Doctor of Theology, who is still alive, I mean Mr Poppelbaum.

After two years and a half, that is about Michaelmas 1770, he was permitted, by fortunate circumstances, to go to Dantzig, as assistant in the public laboratory. But in March of the following year, he returned to Berlin, as assistant in the office of the elder Valentin Rose, who at that time was known as one of the most distinguished chemists of his day. But this connection did not continue long, for Rose died in 1771. On his deathbed he requested Klaproth to undertake the superintendance of his office. He thus, after a most honourable and long continued

trial, became superintendant of the office of Rose, in which a greater number of distinguished chemists were formed than in any other, since, beside the elder Rose and Klaproth, this office afforded a larger or smaller portion of their education to Hermbstadt, Gehlen, Valentin, the younger Rose, and several other excellent pharmacopolists. Klaproth not only superintended this office for nine years, with the most exemplary fidelity and conscientiousness, but, what particularly displayed his honourable character as a man, he himself undertook the education of the two sons of Rose, as if he had been a second father to them. The younger of the two died when he had scarcely reached the age of manhood. The elder, whom, after his own example, he permitted to pass from the study of theology to that of medicine, became in after life his most intimate friend, and the associate of all his scientific researches. Several years before the death of Rose, which happened in 1808, much too soon for science, they wrought together, and Klaproth was seldom satisfied with the results of his experiments, till they were repeated by Rose. Klaproth often asserted to the author of this memoir, that, in regard to many of his discoveries, as, for instance, with respect to the important method of analysing by means of barytes, he scarcely knew whether the merit of the discovery was more to be ascribed to himself or to Rose. Like Valentin Rose, all the other members of the worthy family of Rose honoured Klaproth with the attention of children till his death.

In the year 1780, when Klaproth was thirty-seven years of age, he went through his trials for the office of Apothecary, with distinguished applause. His Thesis, "On Phosphorus and distilled Waters," was printed in the Berlin Miscellanies for 1782. Soon after this, Klaproth bought what had formerly been the Flemming Laboratory in the Spandau Street, and he married Sophia Christiana Lehman, with whom he lived till 1803 (when she was taken from him by death), in a happy state of marriage, the fruits of which, three daughters and one son, now survive their parents. He continued in possession of this laboratory, in which he had arranged, for his scientific labours, a small workroom of his own, till the year 1800, when he purchased the room of the academical chemists, in which he was enabled, at the expence of the academy, to furnish a better and more spa-

cious apartment for his labours, for his extremely valuable mineralogical and chemical collection, and for his lectures.

As soon as Klaproth had brought the first arrangement of his office to perfection,—an office which, under his inspection and management, has always been a model of a laboratory, conducted upon the most excellent principles, and governed with exact conscientiousness,—there appeared in *Crell's Chemical Annals*,—in the *Writings of the Society for the Promotion of Natural Knowledge*,—in *Selle's Contributions to the Science of Nature and of Medicine*,—in *Köhler's Journal*, and in other periodical works,—a multitude of essays by him, which drew the attention of all chemists, and afterwards gained for him the rank of the first analytical chemist in Europe. Of these labours, we may mention only an Essay on Copal,—on the Elastic Stone,—on the Pearl-Salt of Proust,—on the Green Lead-Spar of Tschoppau,—on the best Method of preparing Ammonia,—on the Carbonate of Barytes,—on the Wolfram of Cornwall,—on the Wood Tin-Ore,—on the Violet Schorl,—on the celebrated Aerial Gold,—on Apatite,—and so forth. All these labours, by means of which scientific chemistry was illustrated and enriched, were gone through before the year 1788, when he was adopted as an ordinary member of the physical class of the Royal Academy of Sciences, the Royal Academy of Arts having elected him one of their members a year before. From this time, not only all the volumes of our academical memoirs, but several of our well known daily papers, contained a multitude of new discoveries by this accomplished chemist; and we must say, that, amidst all this crowd of his works, there is not one by which we have not been led to a more exact knowledge of some one or other of the productions of nature or of art, since in these works he has either corrected false representations, or extended views that were before partially known, or has revealed the internal and formerly unknown composition and mixture of the parts of bodies, and has made us acquainted with a multitude of new elementary substances. Amidst all these labours, it is difficult to say, whether we should most admire the fortunate genius, which in all cases readily and easily divined the point where any thing of importance lay concealed; or the acuteness which enabled him to find out the best means

of obtaining his object,—or the unceasing labour, and the incomparable exactness with which he developed it,—or, lastly, the pure scientific feeling under which he acted, and which was removed at the utmost possible distance from every selfish, every avaricious, and every contentious purpose.

He very properly began in 1795 to collect his works, which were dispersed among so many periodical publications, and to edite them under the title of *Contributions to the Chemical Knowledge of Mineral Bodies.* Of this work, which must always be a classical production in chemical literature, six volumes had appeared by the year 1815. It contains, in no fewer than 207 treatises, the most valuable part of all that Klaproth had done for Chemistry and Mineralogy; and it is to be wished that the profits may so turn out as to lead to the collection of a few essays which still remain dispersed, into a seventh volume, and to the furnishing of the whole with a good index; an undertaking which, to a young chemist, anxious to perfect his knowledge, would be as full of instruction as of pleasure.

Beside Klaproth's own printed works, the interest which he took in several important labours of others, ought not to pass unnoticed. He superintended a new edition of Gren's Manual of Chemistry, with respect to which, however, he did not seek to earn so much merit by what he added, as by what he took away and corrected. But the part which he took in the Chemical Vocabulary, which was edited under his own name, and that of Wolff, was of great importance. For although the composition of every particular article was the labour of the learned Professor Wolff, yet Klaproth took such an active interest in the work, that he read through every important article before it was printed, and assisted the editor, on all occasions, with the treasures of his experience and knowledge. In the German translation, too, of Berthollet on Affinity and on Chemical Statics, the author of the present memoir was much indebted to the revisal of Klaproth.

If the author of this memoir were to collect the merit of Klaproth as a chemist into one great feature, he would place it not so much in the discovery of new metals and earths, as in the invention of more exact and more perfect methods of analysis, than were known before his time. The former kind of merit is

more adapted to draw the attention of the public at large; but the latter is of infinitely greater consequence to science. Passing by the numberless small expedients which Klaproth devised for procuring a more unmixed deposition and separation of all kinds of matters, we only notice at present that he enriched experimental chemistry with two new methods of analysis, which are unlimited in their applications.

The first of these was the complete resolution of the hardest minerals, by means of fluid caustic alkali, instead of the former treatment with dry caustic alkali, which had introduced the use of silver crucibles and saucers into experimental chemistry. The complete resolution of the hardest stones, by this method of analysis, has enabled us to ascertain, with extreme accuracy, the quantity of earths, oxydes, metals, and even of acids, which minerals contain. Exact analyses of this kind remain sure for ever, and are of importance to the science, independent of any discoveries which may be made, respecting the particular nature of the substances mentioned. As, for instance, the capability of being decomposed, which was afterwards discovered to belong to the earths, makes not one cypher incorrect or superfluous in such analysis. The advantage of this method is particularly evident in the decomposition of corundum or diamond-spar. As Klaproth first attempted the analysis of these bodies, by the former method of decomposition, he found a considerable remainder of matter unaccounted for. On the suspicion, which he then expressed, that this remainder might perhaps be a new, and yet undiscovered earth, many compilers of school books were in a hurry to admit the earth of corundum into the list of the simple earths. But when Klaproth repeated the analysis, by means of the liquid alkali, he found, that this substance was one of the many compositions of siliceous and argillaceous earths, which had not previously been known, and which in former analyses had sometimes been referred to the one kind of earth, and at other times to the other. In the same manner, the chemists of England gave an account of a species of sand, which had been brought from New Holland, as a new earth; but Klaproth shewed, by his new method of analysis, that this body also, which had already been introduced into introductory treatises, under the name of "the Austral Earth," was nothing but an in-

timate mixture of siliceous and argillaceous earth. Indeed, the first analyses that can be considered as certain, are those which have been undertaken on this plan. Hence, by this discovery, almost all the more early analyses have lost their value. Of what inestimable moment such a discovery must be, not merely to experimental chemistry, but to the whole of the science of nature, even although Klaproth had not discovered by means of it a single unknown body, does not require to be more particularly stated.

In the numerous exact analyses which Klaproth conducted according to this method, there was almost always discovered at last to be a small loss, that is to say, the weight of all the single component parts was ascertained to be somewhat less than the weight of the mineral which had been analysed. He in every case stated this loss with great precision, and by this incorruptible regard to truth, he obviously procured for the results of his labours a much greater certainty than if he had permitted himself, as he might easily have done, to conceal this loss under inconsiderable changes in the decimal figures. He also never gave his results, as he likewise easily might have done, in a great crowd of decimals, by which means the appearance of much exactness is sometimes gained, but he gave only as many cyphers as were sure. As long as the loss amounted only to a few thousand parts of the whole, it might easily be referred to those small mistakes which in every course of experiments are unavoidable, from the limited nature of our senses and instruments. But, in some analyses, as for instance, in that of Felspar, a loss of some hundred parts was discovered. Such a loss, considering the care with which Klaproth laboured, could only arise from some of the constituent parts having entirely escaped observation during this method of resolution. Convinced that this could be neither an earth nor a metal, nor an acid, nor water, nor any other volatile matter, he at last began to suspect that perhaps many minerals might contain a hitherto unsuspected quantity of fixed alkali, which could not be discovered by the method of analyses by means of these alkalies. This consideration led to Klaproth's second great invention, I mean, the method of analysis by means of Barytes, although, as was formerly remarked, the excellent Rose had no inconsiderable part in this invention. The event justified Klaproth's suspicion, since he

actually discovered a considerable quantity of *fixed alkali* in felspar, porphyry-slate, and many other minerals.

By the union of these two effective methods of analysis, Klaproth has in fact brought the art of chemical analysis to such a degree of perfection, that we are entitled to expect not only that all the fundamental constituents of minerals, but even their relative qualities, will, by degrees, be determined with perfect correctness. But he not only laid the foundation of this reform; he has even reared a great and considerable portion of the superstructure. His analyses have hitherto been found so correct, that even in the most careful repetitions of them, whether with or without any change of the method of resolution, only inconsiderable variations have been found. And, although, as has been done lately by some celebrated natural historians, great improvements have been suggested merely upon hypothetical views, yet we are bound to demand that the mistakes should first be pointed out by experimental investigators. Facts are the only sure foundation not only of chemistry, but of all science without exception. Even mathematics and philosophy are no exceptions to this; for they must rest on the facts of natural consciousness, if they are at all well founded. Hypothetical views are indispensable for the promotion of truth: but it is clear that they can never furnish a firm foundation of science. Wherever, therefore, there is an evident opposition between a hypothesis and facts, our first duty is to examine whether the foundation can be so cleared out as to evince either the incorrectness of the supposed facts or of the hypothesis. But if the foundation cannot be so cleared out, the suspicion of incorrectness must then fall upon the hypothesis, until some mistake as to facts has been proved.

It is hence not to be doubted, that even distant posterity will honour the merits of this distinguished man, who has not merely examined and explained a greater number of facts than perhaps any other chemist, but who, more especially by the methods of analyses proposed by him, as well as by his own excellent models of proceeding, has shewed naturalists the way by which they may enrich science with new facts, and may render those that are already known still more perfect and exact.

The great care which Klaproth employed in securing the neatness of his experiments, was not the least of his merits, not only because the great confidence which his labours deserve rests chiefly upon this circumstance, but also because in this he was a pattern to all practical chemists.

To this quality must be referred the attention which he bestowed on his instruments. When he had to do with very hard minerals, he used a mortar of flint, but he previously analysed it, and did not neglect the small and scarcely perceptible increase of weight which the matter under examination derived from continued rubbing, and, according to the differences of the substances that were before him, it was by no means a matter of little moment in his estimation, whether the pounding which was always continued till the body was reduced to an impalpable powder was conducted in vessels of flint, of calcedony, of glass, of serpentine, or of metal. And when he operated with fire, he always selected his vessels, whether of earthenware, of glass, of graphite, of iron, of silver, or of platina, upon fixed principles, and shewed more distinctly than chemists had previously been aware, what an effect the vessel often has upon the result. Not less important was the extreme care which he used in preparing pure reagents, for obtaining which in their most perfect state, he invented several efficient methods.

Nor must we pass unnoticed his scientific manner, both in oral delivery and in composition. His language was simple and unadorned, but clear, well defined, and condensed. He never used more words than were absolutely necessary for a complete elucidation of the matter in hand. He rather pointed out than entered into any discursive exhibition of the grounds of his operations,—in general, he employed few reasonings, and only a simple statement of the essential circumstances of an experiment and of its consequences. It was particularly remarkable in him, however, that neither in his oral communications, nor in writing, neither in plain words nor by hints, did he ever attempt to exalt his own discoveries, or to bring them nearer either to the eye or the ear of his hearers. His pupils never heard from his own mouth how much science had been indebted to him, so utterly averse was he to all vanity, all boasting, and all selfishness. In a word, truth and science were every thing

with him; the moment these began to occupy him, every other interest was hushed, and passed into the back ground.

The essays which he has given to the public, with a few exceptions, contain analyses of inorganic bodies. But it would be a mistake to infer from this, that his chemical knowledge was of a partial nature. It is quite natural, that a man of excellent talents should devote himself with a preference to that particular field in which his first attempts had been followed by distinguished results,—where he had found many weeds to root out, much space to be planted anew, and a great deal of uncultivated ground to be rendered productive. But he is not likely to have accomplished any thing remarkable, even in that department which he had chosen for himself, nor any thing that has a relation to the whole science, unless he is thoroughly acquainted with all its parts. Every science is a great and intimately connected whole, no part of which can be cultivated with any important results in an isolated state. It is true that a person of a peculiar taste, may attach himself to one part of a science which, in its entire extent, is unknown to him, and in that single department may make many discoveries, as Franklin in electricity, or may make some fine observations, as was done by Göthe, in regard to colours. But, in such instances, the person must be at the greatest loss for proper means of estimating causes, both in the material and intellectual world,—he must be constantly exposed to the danger of mistaking what is insignificant for what is important,—what is great for what is superfluous,—truth for error, and error for truth; in short, his labours cannot have that completely solid result which attended those of Klaproth. Those who knew him intimately, are aware that he kept fully up with the progress of his age, and that nothing which was important within the dominions of his science escaped his notice. But he was not satisfied with merely reading and understanding what had been done by others; he repeated every new experiment, to whatever department of his science it might belong, to convince himself of the correctness of the facts that were announced. How susceptible he was of the impression of new views, was distinctly seen at the time of the antiphlogistic chemistry, when, with the utmost alacrity, he overturned his whole previous system, the moment he was convinced, by a careful repetition of the experiments, of

the correctness of the facts on which Lavoisier had founded his new doctrines. Even in his advanced years, he did not tenaciously adhere to his old views. In early life he had adopted, like all other chemists, the doctrine of affinities proposed by Bergmann, as the foundation of his explanations, although he took many opportunities of warning those who attended his lectures respecting its insufficiency. When Berthollet's investigations, respecting the laws of affinity appeared, he completely satisfied himself of the untenable nature of his former views; and although he did not think that, in regard to several particulars, he could assent to the decisions of the ingenious French chemists, he was yet perfectly satisfied as to the correctness of the principle on which all the investigations of Berthollet proceed, namely, *that no one power is adequate to the explanation of chemical phenomena*, but that, even in the case of the simplest composition or resolution, several powers unite their energies. He also admitted the necessary consequence of this principle, namely, that it is impossible to arrive at a true scientific theory in chemistry in any other way, but by the most careful consideration and investigation of the laws, according to which the individual active powers and circumstances, that is to say, the powers of cohesion and of expansion, fluidity, gravitation, quantity, heat, light, electricity, and so forth, produce their effect. Klaproth perceived that those only who were conducted as by the hand by the presiding deity of the mathematics, could make any considerable advances in the path which Berthollet had opened up; and he was hence sorry that his defective education when at school had permitted him only to obtain a very superficial acquaintance with that science, in which, with better opportunities, he would unquestionably have made considerable progress, since, even without the aid of that science, he had been able to appropriate to himself, in a very high degree, the exactness and solidity of the mathematical talent. The value which he put, in general, upon the views of Berthollet, was the motive which induced him to encourage the author of this memoir to translate Berthollet's investigations into the language of Germany. But, however little reason the translator might have to be dissatisfied with the reception which his labours gained with the literary public, it is impossible for him to conceal from himself, that they have never yet completely at-

tained the end proposed by them. It would not be difficult to explain the causes of this. They are to be found partly in some unfavourable accidents,—partly in certain peculiarities of the age, which are not very propitious to deep scientific study. But a more detailed explanation of these circumstances is foreign to the purpose of this memoir. The author contents himself, therefore, with adding, that, without making any pretensions to the gift of prophecy, he may venture to assert, that, sooner or later, the sound principles of Berthollet must be had recourse to, if ever chemistry is to be placed on a more scientific foundation.

Even at an advanced period of life, Klaproth changed his early views in regard to many objects, as, for instance, with respect to the problematical body, named Muriatic Acid; with respect to the impossibility of decomposing the alkalies and earths, and several other points; and by these changes of opinion, he shewed, that even advanced years had not deprived him of the power of being struck by new views and ideas.

With so many distinguished scientific claims, it is not to be wondered, that all the learned societies in Europe, whose object was in any way connected with physical science, should have reckoned it an honour to have the name of so illustrious a man in the list of their members. Beside the two Academies of Science and of Arts in Berlin, he was also a member of the Academies of Paris, London, Petersburg, Stockholm, Copenhagen, and Munich, and of many associations of learned men at Edinburgh, Berlin, Paris, Moscow, Brussels, Erfurt, Halle, Erlangen, Jena, Potsdam, Leipsic, Hamm, Rostock, and other places. Among his papers, there was found, after his death, not less than thirty diplomas from learned societies; and the king (of Prussia) added to these honours, in the year 1811, the order of the Red Eagle of the Third Class.

The State, too, in acknowledgment of Klaproth's merits, rewarded his industry in a variety of ways. So far back as the year 1782, he had been Assessor in the Supreme College of Medicine and of Health, which then existed; at a more recent period, he enjoyed the same rank in the Supreme Council of Medicine and of Health; and when this College was subverted in 1810, he became a member of the Medical Deputation attached to

the Ministry of the Interior. He was also a member of the Perpetual Court Commission for Medicines. His lectures, too, procured for him several municipal situations. For as soon as the public became acquainted with his great chemical acquirements, he was permitted to give yearly, two private courses of lectures on chemistry, one for the officers of the Royal Artillery Corps, the other for persons not connected with the army, who wished to accomplish themselves for some practical employment. Both of these lectures assumed afterwards a municipal character. The former led to his appointment as Professor of the Artillery Academy, instituted at Tempelhoff, and after its dissolution to his situation as Professor in the Royal War School. The other lecture procured for him the Professorship of Chemistry in the Royal Mining Institute. On the establishment of the present University, Klaproth's lectures became those of the University, and he himself was appointed ordinary Professor of Chemistry, and member of the Academical Senate. Besides these public lectures, our departed friend was an active member from 1797 to 1810, of a small scientific society, which met yearly, during a few weeks, for the purpose of discussing the more recondite mysteries of the science, and of which all the members still retain lively recollections.

I cannot resist the inclination which I feel to repeat in this place, a remark which Klaproth used to make respecting his prelections, and which he repeated more than once to the author of this memoir, as well as to several other friends. As long as his lectures were honoured by the presence of students only, they were numerously attended and earnestly listened to; but when the State began to pay for a part of the students, a considerable number of these began forthwith to take a very irregular and diminished interest in the lectures.

It is certainly exceedingly proper that the State should take an interest in the scientific accomplishment of its subjects, by the erection of schools of different kinds; and it is still more proper, that it should afford to those who have not the means, the possibility of an enlightened education; but, perhaps, it would be most desirable in cases of this kind, not to release any of the scholars from the duty of paying for instruction, but rather to

assist the needy, by furnishing them, from a particular source, with the fees, which all should be bound to pay.

In an attempt to do justice to the merits of Klaproth, I cannot altogether pass over one part of them, which might readily remain unnoticed by the public, although it deserves to be generally known,—I speak of the great and beneficial influence which Klaproth, along with several other very respectable men, had upon Free-Masonry. It has not escaped the notice of the public, that during the preceding century all sorts of fooleries, alchemy, ghost-seeing, Rosicrucian enthusiasm, and many other things of the same kind, had crept into Free-Masonry. But their influence, although for a time it turned many heads, could neither be long continued nor of extensive operation; because within the society itself there were always men who laboured to counteract those errors, and Klaproth in particular was one of those respectable men who earnestly and powerfully waged war with deceptions of that kind, who endeavoured to expose it in all its insignificance, and tried to bring back those who had erred into the right way. How much he was assisted in this office by his profound acquaintance with the science of Nature, and by his incorruptible integrity; and how well he has deserved by his labours, not only of science, but of the human race, must be evident to every unprejudiced person who has but a moderate acquaintance with the intricate connections of human affairs.

In the preceding remarks, I have noticed many honourable characteristics of this excellent man, and shall feel happy, if, in concluding this memoir, I could present you with a likeness of him.

Among the most remarkable traits in his character, were his incorruptible regard for every thing that he believed to be true, honourable, and good,—his pure love of science, with no reference whatever to any selfish, ambitious, and avaricious feeling, —his rare modesty, undebased by the slightest vain-glory or boasting. He was benevolently disposed towards all men, and seldom or never was a slighting or contemptuous word respecting any individual heard to fall from him. When he was forced to blame, he did it briefly, and without bitterness; for his blame had always respect to actions, and not to persons. His friends,

as well as his relations, feel severely his loss; for every person to whom he had once given his confidence, might depend upon the unchangeableness of it. His friendship was never the result, like that of so many other persons, of any selfish calculation, but was always founded on a favourable opinion of the personal worth of the man. Amidst all the unpleasant accidents of his life, and of these there was no want, he shewed an invincible placidity, founded, not on any want of lively feeling, but in the firmness of his resolution. In his common behaviour he was always pleasant and composed, and very far from being disinclined to a joke. To all these virtues, the chief ornament was added by his true religious feeling; and I believe I am not saying too much, when I aver that he was a model of the true meaning of that epithet, which is so frequently misunderstood. His religion consisted not in words and forms,—in devotion to the system of any party,—in a general assent to any thing external, or to any thing artificially constructed,—not in positive doctrines, nor in any ecclesiastical observances, which, however, he considered to be necessary and honourable, but in a zealous and conscientious discharge of all his duties,—not only of those which are imposed by the laws of men, but of those holy duties of love and charity, which no law of man, but only that of God, can command, and without which the most enlightened of men is but "sounding brass and a tinkling cymbal." He early shewed this religious feeling, by the before-mentioned great and honourable care which he bestowed in educating the children of those to whom he was bound by no external interest, and by no human law. Nor did he shew less care, at an after period, towards the assistants and apprentices of his office, to whom he refused no instruction, and in whose success he took the most active concern. He shewed his religious feeling still farther by the very strict conscientiousness with which, as the possessor of an office, he laboured for the best condition even of such things as did not fall under views of policy. He shewed it, in the last place, by the pleasure which he took in every thing that was good and excellent, and by the ready interest which he felt in every undertaking which he believed to be of general utility. In fine, he was a man equally removed from the superstition and infidelity of his age,

who carried the holy and eternal principles of religion not on his lips, but in the inmost feelings of his heart, from whence they emanated in actions which pervaded and ennobled his whole being and conduct.

Art. XIII.—*On certain remarkable Instances of deviation from* Newton's *Scale in the Tints developed by Crystals with one axis of Double Refraction, on exposure to Polarized Light.* By J. W. Herschel, A. M. F. R. S. Lond. & Edin. and of the Camb. Phil. Soc. (Concluded from Vol. IV. p. 344.)

But the structure of the crystal under examination is yet more compounded than what I have been describing. Dr Brewster has already, in a highly interesting paper in the Edinburgh Transactions *, described the union of our first variety of apophyllite with another, possessing two axes of double refraction, forming regular columnar crystals, consisting of an interior portion of one kind, surrounded by a case or border of the other, &c. The specimen I am now describing, however, presents the hitherto unique combination of no less than three distinct substances, having each but one axis of double refraction, uniting to form a single crystal, and following regular geometrical laws of juxtaposition. In examining the two plates as above detailed, the portions most transparent and uniform in their structure were selected, and insulated from the rest, by fastening them over holes of about an eighth of an inch in diameter in sheets of lead. But when the whole plates were exposed to a polarized beam, each was observed to consist of two distinct portions or compartments, as represented in Plate VII. Fig. 3. where the interior parts *a b c d e* are those already examined; the border ABC*d c b a* being separated from the inner portion by a plane of junction which, in the thicker plate, appeared, on inclining it, to be marked with a series of pretty broad coloured fringes, whose origin is sufficiently obvious. Considerable irregularity appeared in the structure of this border, but, at a perpendicular inci-

* This paper is printed in this *Journal*, vol. i. p. 1. and never appeared in the Transactions.—Ed.

dence, or when inclined at any angle in the plane of primitive polarization, or in one perpendicular to it, it had no action upon the incident ray, however turned round in its own plane. Of course it has but one axis of double refraction, and that at right angles to its laminæ.

The best and most transparent portion being selected and insulated as before, the plate was inclosed in the oil apparatus, when the tints developed on inclining it in a plane making an angle of 45° with that of primitive polarization, were as follows:

TABLE IV.—*Apophyllite, third Variety. Thickness* =94499.

Incidence.	Ordinary Pencil.	Extraordinary Pencil.
0° 0′	White.	Black.
	Yellowish-white.	Sombre indigo.
17 0	Pale yellow.	Indigo inclining to purple.
	Pale greenish-yellow.	Pale lilac purple.
28 15	White, slightly greenish.	Very pale reddish purple.
39 14	Very pale green.	Pale rose-red.
47 36	White.	White.
	White, scarcely perceptibly tinged with pink?	White, scarcely perceptible greenish?

This Table of tints indicates a much more energetic action on the red and violet ends of the spectrum than on the intermediate colours, especially the yellow, and this was fully corroborated by observations in homogeneous light, which gave the values of l for the simple colours as in the subjoined Table.

TABLE V.—*Scale of the Minimum Lengths of the Periods of the different simple Rays in the third Variety of Apophyllite, and their Reciprocals.*

Name of Colour.	Minimum length of period value of l.	Polarizing power or value of $\frac{1000000}{l}$.	Number of Observations.
Extreme red.	43634	22.918	10
Mean orange.	101238	9.878	10
—— yellow.	366620 +	2.728 —	10
—— green.	89646	11.155	10
—— blue.	32211	31.040	10
—— indigo.	21947	45.565	10
Extreme violet.	13704	72.970	10

The curve representing the values of $\frac{1}{l}$ or the polarizing energy of the variety now under consideration, constructed as in the

former case, is represented in Fig. 4. Its ordinate, as we see, decreases rapidly from the red to the yellow, where it is beyond the reach of the present observations, then increases again yet more rapidly, and is greatest of all for the violet rays. For the sake of comparison, Plate VII. Fig. 5. represents the curve similarly constructed for the ordinary variety, which has a *maximum* where the variety last described has a *minimum*. The straight line $r\,B$ inclined at 45° to the abscissa in all the figures represents the values of $\frac{1}{l}$ for such crystals as follow Newton's Scale in their tints.

The apophyllite has furnished us then with no less than three instances of remarkable deviations from Newton's Scale in crystals with one axis. It would certainly be in the highest degree interesting to subject them all three to chemical analysis, but as the total weight of the specimen presenting these anomalies did not exceed 60 grains, of which nearly one-half consisted of the ordinary variety, I have not sufficient confidence in my own chemical dexterity to enter on so very delicate an inquiry, which would obviously call for a degree of precision attainable only by consummate masters in the art of mineral analysis. It remains, therefore, to be ascertained, whether their different actions on light be owing to a difference in composition, or merely in their state of aggregation. Meanwhile, as we have seen that the union of two crystals differing in their scale of tints produces a scale differing from either, it may not be irrelevant to inquire, whether the alternation of laminæ of two of the varieties above described, may not be capable of producing the remaining one.

To this end, let t, t', t'', &c. be the thickness of the 1st, 2d, 3d, &c. lamina so superimposed as to have their axes coincident, and of the same refractive density: l, l', l'', &c. the *minimum* lengths of the periods susceptible of being performed by a ray of any colour within these several crystallized plates, and θ the angle with the axis, at which a similar ray traverses the system. Then, as M. Biot has proved, the number (n) of periods, and parts of a period, actually performed by this ray during its passage through the first plate, is given by the formula,

$n = \frac{t}{l}. \sin \theta \times \tan \theta$, the laminæ being supposed all of one class, (*i. e.* all positive, or all negative,) or t being regarded as negative for those of a contrary class. The periods performed by the same ray in traversing the second lamina will be

$n' = \frac{t'}{l'} \times \sin \theta \times \tan \theta$, and so on, and, according to what the same eminent philosopher has proved, the ray will assume at its emergence from the system the same plane of polarization as if it has executed $n + n' + n'' +$, &c. periods in one lamina. If, then, we take $n + n' + n'' +$, &c. $= N$; $t + t' + t'' +$, &c. $= T$, we have

$$N = \left(\frac{t}{l} + \frac{t'}{l'} + \frac{t''}{l''} +, \text{\&c.} \right) \times \sin \theta \times \tan \theta = \frac{T}{L} \times \sin \theta \times \tan \theta,$$

provided we take L, so that $\frac{T}{L} = \frac{t}{l} + \frac{t'}{l'} \frac{t''}{l''} +$, &c.

Let p, p', p'', &c. represent the polarizing power of each lamina on the given ray, and P, that of a lamina equivalent to the compound system, and we have $p = \frac{1}{l}, p' = \frac{1}{l'}$, &c. $P = \frac{1}{L}$, so

$$\text{that } T. P = t.p + t'.p' + t''.p'' +, \text{\&c.}$$

and $P = \frac{t.p + t'.p' + t''.p'' +, \text{\&c.}}{t + t' + t'' +, \text{\&c.}}$. If, then, P be so assumed, an imaginary plate, whose polarising power is P, and thickness that of the compound plate ($t + t' +$, &c.) will exercise precisely the same action on the ray as the system so constructed, and it appears from the nature of this formula, that it is indifferent in what order the elementary laminæ are distributed; so that all those of the same species may be conceived grouped together and united into one.

Now, suppose the colour of the ray to vary, and let c be any quantity whose magnitude determines its place in the spectrum (as, for instance, the reciprocal length of one of its fits of easy transmission and reflexion in vacuo). Then, if we represent, as we have done before, the quantity c by the abscissa of a certain curve, p, (a function of c), may be represented by its ordinate; p' (another function of c), by the ordinate of another curve, and so on; and P, the ordinate of a similar curve, for the compound plate may be computed by the above formula.

But it is evident from a moment's consideration of the forms of the three curves representing the polarizing powers of three varieties of apophyllite, that no one of them can be produced by any combination of the other two according to this law, and we are therefore necessitated to admit each as a distinct variety, or at least composed of laminæ of not fewer than three kinds. This alternation or superposition of laminæ of different polarizing powers is no hypothetical case. I have observed its occurrence, not only in the instance before us, but in other crystals of perfect regularity in their external forms. Dr Brewster has also observed phenomena referable to this principle in his paper on the apophyllite.

Hyposulphate of lime (formed by the union of that base with the hyposulphuric acid lately discovered by Welter and Gay Lussac, (See *Ann. de Chimie*, X. *March* 1819,) affords another instance of deviation from Newton's Scale in crystals of double refraction. This salt crystallizes in bevelled hexagonal tables, which have no distinct cleavage, the axis being perpendicular to their broad surfaces. The following is the scale of tints developed by a plate of this salt on exposure to polarized light.

TABLE VI.—*Hyposulphate of Lime. Thickness* = 35701. *The axis was inclined* 5° 12′ *to the surface in the plane of incidence.*

Incidence.	Ordinary Pencil.	Extraordinary Pencil.
0° 0′	White.	Black.
	White.	Very faint sky-blue.
10° 32′	Very pale yellow.	Pretty strong sky-blue.
	Sombre yellow.	Very light bluish-white.
	Sombre pink yellow.	White.
	Sombre purple crimson.	White.
15° 1′	Beautiful rich dark purple.	White, a little yellowish.
	Beautiful deep blue.	Bright straw colour.
	Bright blue.	Yellow.
	Fine light blue.	Yellow verging strongly to orange-pink.
	Light greenish blue.	Fine pink.
	Light yellow green.	Sombre pink.
21° 27′	Light greenish-yellow.	Purple.

Table VI.—*Continued.*		
Incidence.	Ordinary Pencil.	Extraordinary Pencil.
	Ruddy but pale yellow.	Blue.
	Pink, light and approaching to brick-red.	Bright greenish-blue.
25° 3′	Fine pink.	Splendid green.
	Pink.	Light green.
26° 7′	Pale purple.	Greenish-white.
	Dull blue.	Ruddy white.
	Bright greenish-blue.	Tolerable pink-red.
29° 33′	Blue green.	Fine rose-red.
31° 35′	White.	Dull pale purple.
	Ruddy white.	Blue, rather pale.
	Good pink red.	Green blue.
35° 27′	Dull pale purple.	White.
	Light blue green.	Pink-red.
39° 32′	White.	Very pale purple.
	Light pink.	Very light blue.
	White.	White.
	Extremely pale blue.	Almost imperceptible pink.
	White.	White.

The colours here cease to be perceptible after the fourth order, and the degradation of the tints is evidently much more rapid than in Newton's Scale. Thus the blue of the first order, which in that scale is scarce perceptible, is here sufficiently strong to influence its complementary tint, depressing it to a pale yellow. The green and its complementary pink of the second order in this Table are fully equal in brilliancy to those of the third in Newton's Scale, while those of the third are scarcely equal to Newton's fifth. Accordingly, by a series of measures taken with considerable care in homogeneous light, I found the values of l for the several simple colours as follows:

Table VII.—*Scale of the Minimum Lengths of the Periods in Hyposulphate of Lime, and their reciprocals.*			
Name of Colour.	Minimum length of its period, or value of l.	Polarizing power or value of $\frac{1000000}{l}$.	Number of Observations.
Extreme red.	3241	308.54	38 very exact.
Mean orange.	2454	407.45	26
—— yellow.	2129	469.65	28
—— green.	1861	537.32	20
blue.	1658	603.21	20
—— indigo.	1480	675.83	20
Extreme violet.	1129	885.77	29

The curve constructed from this Table, as in the case of the apophyllites, is given in Fig. 6.

The rings in this crystal, when crossed by a plate of sulphate of lime, are affected in the same way as those in carbonate of lime, tourmaline, &c. and the axis is therefore of a repulsive character.

The facts above adduced suffice to shew that vast differences exist in the scale of action, which a single axis may exercise on the differently coloured rays, and that, whether we regard the single apparent axis of any of the above crystals as the resultant of two others equal to it in energy, but of an opposite character, situated at right angles to it and to each other, with Dr Brewster, or as being itself the real axis of polarization. For the resultant axis being the same for all the colours, the partial actions of each of the supposed axes on the former hypothesis, having the same point of compensation for all the colours, must be equal to each other and to the resultant force for them all. The mere fact, therefore, of a deviation from Newton's scale, however enormous in the tints of any regular crystal with one axis, cannot be regarded as affording of itself any argument for the substitution of two others for it in that particular substance, because each of such axes acting separately, would exhibit a scale of tints perfectly identical with that of the axis whose place they supply, and therefore, by parity of reasoning, should be regarded as the resultant of two others, and so on, *ad infinitum*. This reasoning appears to me conclusive against any analogy between crystals with one and two axes, founded on a deviation of tints in the rings of the former. But I cannot help regarding the phenomena I have described as affording considerable support to the very ingenious theory of the philosopher just mentioned, as applied to crystals with two axes, inasmuch as they establish the existence of that diversity in the scales of action of the simple or elementary axes, without which their points of compensation (or the poles of the lemniscates they exhibit in polarized light) must of necessity be coincident for all the simple colours, a coincidence which, as has been already remarked at the beginning of this paper, seldom or never takes place. This I conceive to be the view which Dr Brewster himself has taken of the phenomena of the deviation in crystals with two axes, and to afford ocular

demonstration of the existence of what he has called the different dispersive powers of his elementary axes.

SLOUGH, *Feb.* 19. 1820. J. F. W. HERSCHEL.

ART. XIV.—*On the Phormium tenax or New Zealand Flax.* * By J. YULE, M. D., F. R. S. Edin., and Fellow of the Royal College of Physicians, Edin. Communicated by the Author.

WE owe to the late Sir Joseph Banks and his associates, who accompanied Captain Cook in his voyages round the world, our first acquaintance with the valuable purposes to which this plant is turned by the islanders of the South Sea. The fibres of the leaves are, in fact, of greater strength than those of Flax or Hemp, and, consequently, could the plant be cultivated in the South of England †, or even imported from our settlements in Austral Asia (to the climate of which it is naturally adapted), at an expence sufficiently moderate, it might certainly deserve the attention of the government at present, when the emigration to this quarter of the world is going on; for, next to the raising of grain, whatever is of importance to our navy, is worthy of the greatest consideration. It was, however, chiefly in a physiological point of view, that my attention was attracted to this singular plant; for, having obtained some of the seeds from the East Indies, through the kindness of Dr Wallich, I was anxious to examine their structure; but, like those of many of the same series of plants, they do not easily germinate, when once in an over dried state, and consequently afforded but an imperfect view of the parts of the embryo, so that I have had no opportunity of comparing them with the description of Gærtner. This, however, was in some degree compensated by the dissection of the buds; the structure of which will, in many instances, enable us

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* Read before the Royal Society of Edinburgh.

† What renders this probable is, that it has withstood these three past winters at Edinburgh, in different situations, elevated nearly 225 feet above the level of the sea (the mean temperature 46° 23'), partly retaining its long rigid leaves, except in one case, where it was prematurely excited, by being placed in the vicinity of a stove, the soil being poor sand. In order to give it a chance of flowering, it is now under trial, in a rich deep loam, in a less elevated garden, with the shelter of surrounding shrubs only.

to determine, to a certain extent, the respective affinity of the subordinate tribes of the great natural orders of plants. The Asphodeleæ, as at present considered, will soon, one may venture to foretell, be still further subdivided, as they have been already, and with reason, separated from the real Liliaceæ: for, notwithstanding the external resemblance of the perianth and the general aspect of the spike, and parts of fructification, Hyacinthus and Phormium are widely distinguished by nature. This difference is particularly manifested in the structure and manner of evolving their respective germs. In Phormium, the primary or sheathing leafet, shooting from the part termed by some physiologists the body of the embryo, and by others confounded with the radicle *, envelopes the successive leafets which shoot alternately from the edge of their predecessors, towards their base, and which they gradually, as it were, cut open as they advance in growth; and at length, what was originally the inside, becomes the disc of the leaf. In this singular manner of germinating, they resemble, superficially only, the Hæmodoraceæ and Irideæ, which are in other respects totally distinct. To Dianella, however, Phormium is more nearly allied, notwithstanding this last produces a berry instead of a rigid capsule like Phormium.

The Phormiaceæ, then, although allied to certain European Asphodeleæ, form a detached link of the chain; and Mr Brown is the only botanist from whom we are likely to obtain satisfactory information with respect to the intermediate genera, connecting these with Stipandra and Dianella. It is remarkable, that these genera should so closely resemble each other in the strength of the fibres, as well as in the germination of their rigid leaves. But the Dianellæ are comparatively diminutive plants, and appear to possess little value, either in an ornamental or in an economical point of view.

The following results, established by MM. Thouin and La Billardiere, manifest the comparative superiority in strength of

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* La Tigelle (Cauliculus), M. Richard observes, " se confond du'ne part avec la radicule, don't elle n'est qu'une prolongement."—*Vid. Analyse du Fruit*, p. 49. &c. I shall in a future paper, with due regard to the memory of this very respectable naturalist, (who lately died at Paris), endeavour to point out the inaccuracy of this definition.

the fibres of the Phormium, over those of the under-mentioned plants and of silk, for the purposes of cordage or cloth.—Fibres of

Agave fœtida being equal to	7
The best Flax,	$11\frac{3}{4}$
Hemp,	$16\frac{1}{3}$
Phormium,	$23\frac{5}{11}$
Silk,	34

In extensibility, however, the fibres of these substances differ most materially; and as this property must necessarily regulate the strength of twisted bodies, it was found on trial, in each of them, nearly in the following proportions, in

Agave,	$2\frac{1}{2}$
Flax,	$\frac{1}{2}$
Hemp,	1
Phormium,	$1\frac{1}{2}$
Silk,	5

Now, admitting that perfect accuracy cannot be expected in experiments of this kind, the comparative results are most important. The superiority of Phormium is evident in strength as well as in extensibility; so that its respective filaments are, in the same proportion, less liable to be broken, either in the process of twisting or in pulling, than those of hemp. The filaments of each of these substances were taken as carefully as possible, of the same diameter, as far as could be determined by a microscope and micrometer. The force used was weight applied as equally as possible.

When we consider the geographical position of New Zealand, between the Lat. 34° and 48°, in a parallel of the southern hemisphere, whose mean temperature, under a similar elevation, probably differs less from that of the southern parts of Britain than might be expected; and especially when we know, that, in numerous instances, some of our most useful plants, now completely naturalized, were originally obtained from countries bordering on the Tropics, we are naturally led to think, that the number of such instances might be still greatly increased, were the circumstances necessary to success better understood, and particularly the laws of the vegetable economy; for these laws bear a relation much closer than is generally supposed to physical geography and meteorology. Indeed our inquiries into this

important subject have been but too generally neglected, in favour of the conceits of the framers of systems; professing to arrange innumerable organized and living bodies, of which little more could be known than the mere figure and names, without regard to their comparative internal structure, the only solid basis of a true arrangement.

Under a climate like that of North Britain, although tempered by an insular position, we have had already many difficulties to encounter; but we have encountered, and, what is better, we have, in many respects, overcome them. Although placed beyond the parallel of the olive and the vine, we have produced what is far superior to both,—a perpetual verdure of country; and this chiefly from the culture of plants gradually introduced from abroad; and, after long experience, brought to grow luxuriantly.

Art. XV.—*On Metallurgic Crystallography.* By Professor Haussmann. (Continued from p. 164.)

3. Sulphuretted Metals.

a. Sulphuret of Copper.—THE copper-stone (*Lapis cuprinus*)* belongs to that class of productions which most commonly occurs in founderies. It is produced either as an original formation from the first melting of ores of copper, or as a less original production from other metallurgical processes, and contains mostly sulphuret of copper, with which are associated some other metallic sulphurets, particularly sulphuret of iron, and sometimes sulphuret of lead, besides simple metals, most frequently copper, and occasionally silver and gold.

It is not improbable, that copper, in the same way as iron, admits of being conjoined with sulphur in many determinate proportions; but in copper-stone, the copper appears for the most part to contain the same proportion of sulphur as in native sulphuret of copper, to which it bears a very close external resemblance. This opinion is confirmed by the fact that copper-

* Lapis sulphureo-metallicus, *Wallerius.*

stone has occasionally the same crystalline form as native sulphuret of copper.

b. Sulphuret of Lead.—Galena reproduced in melting furnaces has been already mentioned. It is formed by sublimation during the fusion of native galena, and frequently occurs in the form of crystals. Artificial galena, formed in the founderies of the Upper Hartz, generally contains, besides sulphuret of lead, also sulphuret of antimony, which may be easily explained, as galena veins frequently contain also antimonial galena. The crystalline form is cubical, as in galena. But it is remarkable, that the secondary crystallisations, which occur most frequently in native galena, are not observed in artificial galena, where the primitive form occurs, which very rarely occurs in the native.

c. Sulphuret of Antimony.—Besides that galena, which is occasionally antimoniferous, there is a combination of it formed by sublimation, consisting of sulphuret of lead, along with a larger quantity of sulphuret of antimony, which is produced in the furnaces of the silver founderies in the Upper Hartz. This mixture may be distinguished by its very bright colour, and by its tendency to a radiated structure. In the pores of a specimen of this substance, produced in the foundery of Lautenthal, I once found very thin prismatic crystals of pure sulphuret of antimony, about half a thumb in length, and bearing an obvious resemblance to crystals of native sulphuret of antimony. This production admits of a simple explanation, from the fact that antimoniferous galena is very frequently associated with common galena, occurring in the metallic veins at Lautenthal.

4. Oxides.

Oxidised zinc is found in crystals in many of the iron founderies in Germany; but of this substance, which at first sight bears a close affinity to phosphate of lead, the true nature has been hitherto unknown: and it is a new discovery of my esteemed colleague Stromeyer, that the crystals mentioned above are composed of oxide of zinc, coloured with a small quantity of oxide of iron.

The form of these crystals, which is so minute as not to exceed the size of three lines, is a hexangular prism, the terminal planes of which, as in sulphate of lead, are frequently incom-

plete in the central part. The colour of the crystal is olivaceous, with various degrees of lustre, passing from an olive into a waxen hue. The crystals are sometimes transparent, sometimes semitransparent, and the lateral planes possess a vitreous lustre, and the terminal planes have a pearly lustre.

I have ascertained, by a sufficiently accurate measurement, that the crystals are regular hexagonal prisms. When it was difficult to take a direct measurement, on account of the smallness of the crystals, I was assisted by the following experiment: I impressed the terminal planes upon paper, covered over with the smoke of a candle, the angles of which delicate impression I could subject to a more accurate measurement. Besides this, I observed a second variety, where the terminal edges of the regular hexagonal prism are truncated; but I could not ascertain the angles of the truncations, on account of the smallness of the inclined planes.

b. Copper-Mica.—Copper-mica is an interesting production, and merits particular attention. It is a very disagreeable guest in the copper founderies of the Hartz, where it has been long known. It consists of very thin plates, having a middle colour between gold and copper, and a metallic lustre. When more accurately examined, the plates appear for the most part to have a regular hexagonal tabular form, and the crystals attain the diameter of a few lines.

Stromeyer, by a laborious chemical analysis of copper-mica, has illustrated its probable nature; a hundred parts contain

54.25	Oxide of Copper
39.81	White Oxide of Antimony
4.05	Oxide of Lead
0.16	Oxide of Silver
0.07	Oxide of Iron
1.58	Silica, having a trace of Alumina
0.08	Sulphur
100.	

c. Crystalline Vitreous Scoriæ.—The substances produced in founderies, but especially scoriæ, have been hitherto regarded with less attention than their real merit demands, from the mistaken practice of throwing away the residue, as in a great measure useless, because, on being analysed, they are said to be of no advantage in metallurgical processes. But this cannot,

with justice, be said of metallurgical processes, unless the residua were just as accurately examined as the ores. From the following observations, I think it may be proved, that combinations are formed in determinate proportions, by the aid of chemical elective powers, in scoriæ as well as in other metallurgical formations; and that some combinations occur in scoriæ which are regulated by the same principles in different metallurgical processes. By these observations, I hope to be able to bring together some new information in regard to the crystallisations of scoriæ, which has not hitherto been discovered by an investigation of the regular forms of artificial glasses.

The tendency which appears in glass to assume a regular form, by a slow process of cooling, has been long noticed. In this point of view, the observations of James Keir are very valuable: and to these we may add the observations of Reaumur, and of many later writers, who have explored nature, and published accounts in regard to what is called the Devitrification of Glass. The same tendency to crystallisation is observed in the fibrous texture, which is apparent in glass when slowly cooled; a similar tendency is also observed in scoriæ, produced in metallurgical processes. I have more frequently met with this tendency in scoriæ ejected from the bottom of deep iron furnaces, where, in addition to the fibrous texture, the other common properties of glass, namely transparency and lustre, are combined, though in a less degree; and, in the perfectly formed glass, a silky or resinous lustre is observed, instead of its own proper lustre. In the iron-founderies of the Hartz, I have occasionally seen green scoriæ, with a curved fibrous texture, and possessing various shades of lustre. In many founderies of Norway, Sweden, and Germany, I have found lapidoidal scoriæ, of various grey colours, of a fibrous texture, with the fibres diverging.

Scoria, produced in the fusion of cupreous minerals, at Fahlun in Sweden, very frequently acquires, by being slowly cooled, a fibrous texture, which passes into a radiated texture; the exposed surface shews also a tendency to a hexangular prismatic formation, in the same manner as has been observed in common glass by Keir. This scoria obviously appears in the process of cooling to possess the power of central attraction and crystallization, both in mutual co-opera-

tion; but, at the same time, it appears, that the power of central attraction alone, independent of the property of crystallization, is capable of producing a regular hexagonal prismatic form. By the power of attraction, the particles of the scoriæ, in the act of cooling, are drawn into certain centres; but likewise the particles of the contiguous individual spheres of attraction mutually attract each other. In the greatest approximation of the equal individual spheres of attraction, a change takes place, by the attracting forces acting in opposite directions, of the circular outlines into regular hexagons, which possess less regularity in proportion, as there is a less equal approximation of the spheres of attraction. This phenomenon appears in like manner in the melting of hard bodies as in the drying of moist bodies, in the process of cooling lava as in the drying of potter's clay. From the fibrous texture of scoria, it is evident that the property of crystallisation is conjoined with the power of central attraction. But this latter power does not act freely, being restrained by the former. In many of the planes of the spheres of attraction, we observe fibres going off from the centre to the peripheria, in the same manner as they have been observed by Keir upon glass, and represented by him in Figures 6, 7, 8. of the Plate already quoted.

It very seldom happens, except in the texture, that the tendency to crystallization is doubtful; perfect crystalline formations are observed in scoriæ, of which I shall give some account in the following paragraphs.

Grignonus was the first who described and represented the vitreous octahedral scoria of iron, a specimen of which he had received from a melting furnace. Torbern Bergman, in his Opuscula, and also in his Physical Geography, has noticed an octahedral crystalline scoria, which was obtained from a mixture of limestone with crude iron reduced into flexible iron. This specimen of scoria seemed to correspond with that which is sold by mineral merchants under the name of Volcanic Iron-Glass, and with that also, which, under a mistaken denomination, has been described by Karsten, and has been subjected to a chemical process by Klaproth. Their mistake was first detected by my colleague Stromeyer. I have given a more copious account of

this specimen of crystalline scoria in the Journals of Moll, but since that time I have collected such a mass of materials in regard to this scoria, as to convince me that it is not only produced in different iron processes, but also in the melting of copper-ores.

This crystalline scoria possesses all the properties of perfectly formed glass; its conchoidal fracture, vitreous lustre, transparency, brittleness, and hardness. As the light passes over its surface, its colour changes from a muddy wine colour to an oily, and then into an olive hue; but by a reflected light cast upon its clear and unbroken surface, the colour is of a dark olive hue. Occasionally, however, the surface exhibits colours resembling those of tempered steel. The powder has a green-grey colour, and follows the magnet in its natural state, or after being gently heated, in which state its colour changes into black. When mixed with muriatic acid, it becomes gelatinous. According to the analysis of Klaproth, this scoria contains, in the hundred parts, the following:

66.00	Oxide of iron
29.50	Silica
4.00	Alumina
0.25	Potash
99.75	

Besides these component parts, I have found in it calcareous earth.

Scoria, in the crystalline state, is either octahedral, or it occurs in forms which are easily deduced from an octahedron.

1. The primitive form is a rectangular octahedron.

I have observed the following secondary crystallizations:

2. A wedge-like octahedron, or a primitive octahedron, lengthened out in the direction of the obtuse edges of the basis.

3. The same, truncated on the terminating edges.

4. The same, truncated on the obtuse edges of the basis.

I found a remarkable specimen of crystalline scoria in the furnace of an iron-foundery in Sweden, where the iron flowing over the furnace was covered with it. It is perfectly vitreous, of a pearly colour, of a greenish or reddish grey, and with very small crystals, collected together in great numbers. It has the form of sparry gypsum, with quadrilateral elongated plates, the lateral edges being very oblique, the sides acuminated, and the angles incapable of being accurately measured,

on account of the smallness of the crystals. The crystals are transparent, of a vitreous lustre, very brittle, and cut glass. Before the blowpipe they form a white, bubbling, and opaque glass. From these characters we may draw the conjecture, that this scoria is almost wholly of an earthy nature.

5. Arsenious Acid.

Arsenious Acid belongs to a class of crystalline metallurgical formations, produced by sublimation in many metallurgical processes, where arseniferous minerals are melted. Torbern Bergman, in a work formerly quoted, in regard to the formation of crystals, mentions crystals of what is denominated White Arsenic, which is prepared artificially by a dry process. Born also takes notice of it; he observes, that, on the surface of sulphur melted at Schmolnitz in Upper Hungary, arsenic was spontaneously produced of a white, clear, pellucid appearance, in solitary crystals of a pyramidal and octaedral form. Our countryman Beckman, states, in a new edition of the Crystallography of Romeus Insulanus, that this same crystalline substance is produced in masses at the founderies of Goslar, of which I have given a more copious description in the journals of Moll.

Most excellent specimens of crystals of white arsenic occur in many of the founderies in the Hartz.

1. In masses, where arseniferous minerals are roasted at the founderies of Goslar.

2. In masses, where plumbiferous and argentiferous ores are roasted at the founderies of Andreasberg.

The crystals are formed either perfectly, or more or less imperfectly. The perfect crystals are,

1. Regular octahedron.
2. Wedge-formed octahedron.

The crystals having a less perfect formation, are octahedrons, in the planes of which there are trilateral cavities, with ladder-formed sides. These cavities are analogous to those already described, as occurring in artificial galena; and are sometimes so large, as to exhibit the appearance of a whole mass, composed of eight excavated tetraedrons, and the sides of which are frequently unequal; nor does it rarely happen, that a solitary excavated tetraedron occurs either with perfect planes, or one or other

being perfect, and containing the rudiments of the rest. The internal planes of the tetraedrons are ladder-formed, and are frequently ornamented with lesser excavated tetraedrons. The excavated tetraedrons are frequently so intimately combined, as to have the points of the one running into the cavities of the other; so that the trilateral elongated pyramids, or trilateral tetraedrons with acute apices, are unobserved. Two or four excavated tetraedrons are sometimes combined in simple trilateral or quadrilateral pyramids; the greater number of which occur in masses, so as to become elongated pyramids or elongated prisms.

CONCLUSION.

From the series of observations which have been now made, and to which I hope to be able to make additions hereafter, some general conclusions may be drawn.

1. By an examination of metallurgical productions, we arrive at the knowledge of several crystalline substances, which are not native formations, and of mixed substances containing determinate proportions, which are also artificially produced; we discover, also, several crystalline substances or formations, hitherto unknown.

2. We learn that several crystalline formations are produced, by different metallurgical processes.

3. That some substances obtain the same crystalline forms by a dry, as well as by a wet process, and from metallurgical processes as well as from nature.

4. We see that metallurgical productions frequently afford opportunities of studying the formation of crystals; and from these metallurgical productions we learn, that crystalline formation follows the same laws, whether it takes place by a dry or by a wet process.

5. From these conclusions it may easily be deduced, that not only the science of crystallography, but the other branches also of anorganology, and even metallurgy itself, may derive advantage from an investigation into substances produced by metallurgical processes *.

* The above is an abridgment of a printed memoir, sent to us by Professor Haussman, and which, we believe, has been lately published by the Royal Society of Gottingen.

ART. XVI.—*Account of the Electro-Magnetic Apparatus of Lieut.-Col. Offerhaus.* By G. MOLL, A. L. M. Phil. Doct. Member of the Royal Institute of the Netherlands, and Professor of Natural Philosophy in the University of Utrecht. In a Letter to Dr BREWSTER.

SIR,

As soon as Dr Oersted's experiments were known in this country, I set about repeating them with my friend Mr Van Beek. We first employed a trough apparatus of 120 zinc four inch plates, each zinc plate being placed between two copper ones. The apparatus is the same as described in Mr Brande's Chemistry. Though the effect of this Voltaic battery was as strong as could be expected from its size, it did not act on the magnetic needle with the force which we anticipated, the deviation being only 14°, even with a strongly impregnated needle. We then had an apparatus constructed, consisting of a copper trough, as narrow as conveniently could be made, but long, and deep enough to contain a zinc plate of 3600 square decimeters. The zinc was kept separate from the copper by wooden tarsels, and the space between the two metals was filled up with water, containing $\frac{1}{80}$th of its weight of nitric, and another $\frac{1}{80}$th of sulphuric acid. A wire projected from the zinc, and another from the copper, and on these two a conjunctive horizontal copper wire was laid, so as to be placed in the magnetic meridian. Under this the magnetic needle was put. I believe this apparatus was the same which Dr Oersted recommends. I presume ours was larger than his; but I cannot ascertain this fact, as I have not Dr Oersted's paper at hand. This voltaic battery did not decompose a single drop of water, nor could I perceive any other chemical effect. Its copper pole was positively electrified; its zinc pole negatively, contrary to what is observed in other galvanic apparatuses. Its magnetic power in impregnating needles, suspended in spirals between the wires attached to each pole, was very powerful. The deviation of the magnetic needle, placed under or above its conductive wire, was much stronger than the ordinary trough apparatus. But it is unnecessary to trouble you further with an account of experiments

which are quite analogous with those made, and at present known to every philosopher. We wanted, however, if possible, to obtain stronger effects, by exposing, in a similar apparatus, larger surfaces of zinc and copper to mutual action. My friend, Lieut-Col. Offerhaus of the Engineers, contrived the apparatus, of which I subjoin a drawing. Perhaps you may find this not unworthy of a place in the Edinburgh Philosophical Journal, as it may possibly be brought, in the hands of English artists, to greater perfection. Plate X. Fig. 1. shews its external appearance; Fig 2. the Plan; and Fig. 3. the Section through the axis of the apparatus. The whole, as Fig. 1. shews, is contained in a cask of 51 centimetres high, and in diameter 38 centimetres at top. In the centre of Fig. 2. is represented a wooden cylinder, which constitutes the nucleus of the whole. To this cylinder is nailed a copper plate 4.67 metres long and 0.40 metres high, of course its superficies is of about 1.9 metre, say about 2 square metres. This copper-plate is wound, spiral-like, round the nucleus, as shewn by the white colour in Fig. 2. In the intervals of the helices of this spiral, a zinc plate is placed, long 3.37 metres and 0.4 metres high. Fig. 2. shows also how this zinc follows the spiral windings of the copper one; but they are prevented from touching each other immediately by wooden sticks or rods, of 1 centimetre in diameter, stuck between both metals, as the small circles in the same figure are intended to show. The zinc is marked by a darker shade, to distinguish it from the copper. How these sticks separate the copper from the zinc may also be seen in Fig. 3.

From that part of the zinc plate which is nearest to the wooden cylinder or nucleus, projects a copper wire, and from that part of the copper plate nearest to the side of the cask which contains the whole, projects a second copper wire, as seen in Figs. 1. and 2. On these the conductive wire AB, Fig. 2. is laid, and may be placed in the magnetic meridian. Both wires, which spring from the copper and zinc plates, have at their ends in A and B small pots, to contain a little mercury; and the ends of the conductive horizontal wire have small pins, to enter into these pots, and thus being immersed in mercury, make the contact more close. The horizontal conductive wire may be removed as occasion requires. This spiral apparatus being thus arranged in its tub or cask, the interstices between the metals are filled

with the diluted acid. The horizontal wire being in the magnetic meridian, the apparatus is ready for experiments. As in the former instrument, the copper pole is positively, the zinc negatively electric. A magnetic needle of 0.168 metres long, being placed at the distance of 43 millimetres, under the conductive wire, declined to the east, sometimes as much as 80°. Placed above the wire, and at the same distance, it went as much to the west, viz. 80°. Some philosophers indeed contend, that the deviation is always less when the needle is above than when under the wire. But so many circumstances, during the course of the experiments, will alter the deviation of the needle, that these changes cannot, with appearance of justice, be attributed to its position under or above the wire. I think at least that I have seen as strong deviations when the needle was above the wire as when it was under it.

A remarkable feature in the effect of this spiral voltaic apparatus, is the strong adhesion of iron-filings to the conductive wire. If the zinc plate is new or well cleaned, the acid strong, and of course the galvanic process going on with great energy, then, if iron-filings, on a paper, are brought backward and forward, under, and close to the horizontal conductive wire of copper, the iron-filings will begin to stand erect, as if in the vicinity of a loadstone; they will even adhere strongly to the copper wire when brought into contact with it, and fall down of course immediately when the wire is taken out from its pot. I must observe, however, that the diameter of the conductive horizontal wire appears to have a great influence on the phenomena. It should be neither too thick nor too thin. I found the experiments to succeed best when a wire was used of 5 millimetres diameter.

I need scarcely remark, that this apparatus will very freely ignite platina wire. If it is $\frac{1}{4}$th of a millimetre in diameter, it is ignited immediately, by stretching it from one of the copper plates to the zinc.

The intensity of the magnetic force will, as might have been anticipated, be materially increased by placing the needle under or above the conductive wire. A magnetic needle in its ordinary state, without the influence of the galvanic apparatus, was found to make 12 oscillations in one minute; being placed at the dis-

tance of 43 millimetres under the wire, it made 34 oscillations in the same time. I am, &c.

G. MOLL.

Utrecht, 22*d June* 1821.

ART. XVII.—*Observations on the Hatching of Fowls from Eggs, which have been laid subsequent to the death of the Male Bird.* By the Rev. Mr JAMESON, M. W. S. Communicated by the Author.

MANY facts relating to the economy of domestic fowls are known only to the naturalist, which, if generally understood, might prove beneficial to the rural economist. Natural historians know, that the direct communication of the male is not necessary before every egg is protruded by the female, but that the connexion of the sexes having taken place early in the season, all the eggs protruded by the female are rendered prolific. This fact, known as early as the time of Fabricius, is generally treated as absurd, and, with the exception of the county of Norfolk, seldom if ever acted on. Unless the breeder is assured that the egg is directly or individually trodden, it is thrown aside as useless. I have taken the advantage of the wide circulation of the Edinburgh Philosophical Journal, to bring the fact into more general observation, that eggs which have been laid weeks after the cock bird is removed, have their fecundity as perfect as if impregnated by the male immediately prior to protrusion. This fact is mentioned by Willoughby. The passage states the fact in the strongest manner: "Perchance it may seem to some no less wonderful, that by once treading of the cock, all the eggs which a hen shall lay for a whole year after will be rendered prolific." Fabricius, as he is cited by Dr Harvey, saith, "that it is most true that these proceeds from the seed of the cock; a vertue which renders prolific not only all the eggs, but also the womb, appears from the ordinary practice of poor women, who, keeping a hen without a cock, do for a day or two put it to some of their neighbours cocks; for from that little time of companying with the cock, all

the eggs of that whole year succeeding will be rendered prolific. And I," saith Dr Harvey, "(that I might defend Fabricius, and find out something certain concerning the time and necessity of this prolific coition), did once in the spring-time keep two hens for three days shut up from the cock, each of which did, in the mean time, lay three eggs, no less prolific than any others: And again, another hen, which laid one egg the tenth day after she was shut up, and another the twentieth, and both fecund. So that it seems one or two coits may make the whole cluster of eggs, at least as many as shall be laid for a whole year, fruitful *."

In Norfolk, where the best turkeys in all England are reared, and in the greatest quantities, the breeders act on the fact stated in the above quotation. Mr Marshall says, "It is understood, in general, that to rear turkeys with success, it is necessary that a male bird should be kept on the spot, to impregnate the eggs singly; but the good house-wives of this country know that a daily intercourse is unnecessary; and that if the hen be sent to a neighbouring cock, previous to the season of exclusion, one act of impregnation is sufficient for one brood."

So far as the common *barn-door hen* is concerned, I am not yet prepared either to admit or deny the opinion of Willoughby, respecting *one coition* only being *necessary* to render the eggs for a season prolific, but that such is the fact with the turkey, I put to the test of successful experiment this season.

Last spring the male turkey becoming as usual very troublesome, a battle ensued, when he fell,—a circumstance which has repeatedly happened to me, particularly if the common cock had any *game blood* in him. At the time of his death I had many eggs in the house; these I saw all used. The hens continued to lay for some time, but they did not lay so many eggs as usual; whether owing to the absence of the cock I know not. The first turkey was set with four eggs, laid about a week after the death of the cock, and eight eggs borrowed from a neighbour, who resides some miles from this manse. All the twelve came out, but one of the *regularly trodden eggs*. Some time afterwards, I set another turkey with nine eggs, produced near-

* Willoughby's Ornith. p. 13.

ly *three weeks after the death of the cock.* These also succeeded. The third nine eggs were destroyed by some beast, after she had been set for a fortnight; one egg which was preserved I caused to be broken, when the first stage of the bird was distinctly seen.

These results justify me in recommending to those breeding poultry the Norfolk system. A male turkey is a troublesome bird, and very expensive to keep in condition; to get rid of him is very desirable, and it would appear that a week or ten days of his presence is all the time required for stock.

Though this fact is not new, it is by no means generally known, and when any poultry breeder has been told of it, he laughs at its absurdity. Some of my neighbours are so obstinate in their adherence to the idea of distinct impregnation of every egg previous to protrusion, that though *shewn the birds produced by the eggs laid after the cock's death*, they said it was only a trick. So blinded are we by custom.

Art. XVIII.—*On the Ancient History of Leguminous Fruits.* By Professor Link *.

THE name Leguminous Plants denotes sufficiently the fruits of which we are now to treat. The legume is a two-valved capsule, on the internal margin of which the seeds are placed alternately on the one and on the other valve. The plants which carry such legumes, form a natural order, so plain and distinct, that there can be no doubt among botanists as to its place. The leaf of this sort of plant has only mild properties; the seed contains much starch in its lobes; and hence plants of this order afford a useful nourishment for men and cattle. It is only in some of them that bitter matter is found, and but in a few that it becomes poisonous.

We have not yet escaped from the mysterious circle within which we have long found ourselves in all our speculations respecting the edible plants. Of none of those plants, which are every where cultivated, and in such great quantities, do we yet

* Read at a Public Sitting of the Royal Academy of Science at Berlin, on the 29th October 1818.

know the native region with any certainty. If we consult the systematical writers, we indeed find the native regions of all of them confidently mentioned, and especially the fields of central and southern Europe are considered as having this distinction. It is here that the Chick-pea, Pease, Lentils, Vetches, Lupines, and others of the same kind, have been supposed to grow. But can we affirm with certainty, that a species grows wild in a place, when only now and then a plant of it is there seen to shoot, and is lost again perhaps the following year, especially if it is at the same time cultivated in that region? How easily may a seed, dropped by accident with the grain, produce such a plant? It does not seem to be recollected, that such plants grow decidedly and in quantities annually, on those fields which are their native places, as we perceive in the weeds, *Sinapis arvensis, Raphanus raphanistrum, Centaurea cyanus*, and others. In the Floras, too, we find the habitats of the cultivated leguminous plants given in but an uncertain manner; commonly the Linnæan *habitat in agris* or *inter segetes* is copied. It must be granted, that in the fields of Germany, and in the northern countries of Europe, neither beans nor pease, vetches, chick-pease, nor other similar plants, are properly in their native regions; and I may venture to assert the same thing regarding the south of Europe, in so far as it is known to me. Gerard, who has published a very good Flora of one of the countries in the south of Europe, which are the richest in vegetables, says, while speaking of *Lathyrus sativus*, (Flora Gallo-provincialis, p. 494.): *Provenit in agris, cultis et incultis, hinc indigenus factus, sicut Lathyrus cicera:* And further, *Lathyrus, Cicera lens, ervum inter indigenas enumerari possunt, cum non solum inter segetes cum cerealibus oriantur, sed etiam in agris incultis quandoque sponte proveniant.* This is an excellent description of the manner in which these plants are wild in the south of Europe, but it is a description from which we may conclude, that the author is not speaking of that situation in which they are naturally wild. With the species of grain, the leguminous fruits also now belong to countries where they are no longer in their primitive situation, or to lands where they have been quite extirpated, and have passed into a state of cultivation.

The Romans by no means called our leguminous fruits only *legumina*, but under this name they included all fruits which were cultivated in the fields, and were dressed and used for nourishment, but had not previously been used in the shape of meal and bread. Columella (De Re rustica, l. ii. c. 7.) mentions under this name *milium*, *panicum*, *cannabis*, and *sesama*, to which he adds, *linum* and *hordeum*. In the same manner, among the French, the term *legumes* has a more extensive meaning. But the Greeks had two words, χίδροπα and ὄσπρια, the latter of which corresponds to the word *legumina* among the Romans, and the former denotes exactly our leguminous plants, (Galen, De Alimentor. facultat. l. i. c. 16.)

Bean (Vicia faba).

Beans (*Vicia faba*) may here, as among the ancients, be first considered. Columella names them before the rest, and Pliny says, *Fabæ maximus honos est* (Hist. Nat. l. xviii. c. 12.) We have two species, *Faba equina*, and *Faba hortensis*. The *Faba* forms a particular subgenus of the genus *Vicia*, and is distinguished by its erect stem, which rises without tendrils, and by its internally spongy pod. In the first edition of the *Spec. Plant*. Linnæus mentions the native country of the bean as uncertain; but, in the second, he says, *habitat in Ægypto*, doubtless by confounding it, along with the ancient writers, with *Nelumbium speciosum*. But in the Syst. Veget. it is said, *habitat non procul a Mari Caspio in confiniis Persiæ*; and Lerche is cited as an authority, but whether from oral or written testimony is not evident, for Lerche, so far as I know, has not published any thing upon the subject. Gmelin, Pallas, Georgi, Hablizl, do not mention it, nor does Marschall von Bieberstein. But as the last mentioned author mentions *Vicia narbonensis* as growing wild in Tauris, and it is very like the *Vicia faba*, it is very probable that the two have been confounded.

The ancients were not acquainted with our mode of horticulture, but κύαμος among the Greeks, and *faba* among the Romans, without doubt, denoted our field bean, (*Vicia faba*.) According to Theophrastus κύαμος is a leguminous plant, (τῶν χεδροπῶν, Hist. Pl. l. viii. c. 1.), it is the only one of the legumes that has an erect stem; it has also round leaves, and puts forth

many leaves, while the seed lobes remain in the earth. All the other parts of his description agree. A decisive mark is furnished by the black spots on the wings of the flower. The *Flamen Dialis* durst not touch beans, durst not even name them, according to Festus, durst not eat them, according to Pliny, "*quoniam in flore ejus litteræ lugubres reperiuntur.*" (Plin. l. xviii. c. 12.) On account of these spots, says Didymus (Geopon. l. ii. c. 35.), Pythagoras forbade the eating of them. Beans have been known from the most ancient times; κύαμοι μελανόχροες are mentioned in the 15th Book of the Iliad, (v. 589,) that is to say, *black beans* as we still find them. The arrow which Helenus shot at Menelaus, rebounded from his mail like beans or chick-pease from the thrashing floor. The poet would certainly have said Pease, had these been known to him. In ancient times, as sometimes at the present day, meal of beans was added to bread, and this was named *Lomentum.*

Pliny assigns a habitat to the bean which is worthy of notice, (l. xviii. c. 12.): *Nascitur et sua sponte plerisque in locis, sicut septentrionalis Oceani insulis, quas ob id nostri fabarias appellant. Item in Mauritania sylvestri passim, sed prædura et quæ percoqui non possit,* (probably therefore this is another species.) *Nascitur et in Ægypto* (here the *Nelumbium* is described). What islands are those which were thus called *Fabariæ?* Such an island lies, according to the same writer, near the *Promontorium Cimbrorum* (Jutland). According to this author, beans are of northern origin, and this is not altogether improbable. In the south of Europe, the bean blooms in February, sooner than all the other leguminous plants, and in the islands of the south, the bean can be extirpated,—a thing which does not happen with the wild cabbage in England.

The ancients distinguished between the κύαμος ἑλληνικὸς and αἰγυπτιὸς. The former is our bean, the latter *Nelumbium speciosum,* according to the excellent description in Theophrastus, (Hist. Pl. l. iv. c. 9. ed Schneid.) The description of Dioscorides likewise agrees with it. The fruits, like the cells of bees, from which the seeds project a little, afford a sure mark. This plant was found, according to Theophrastus's information, not only at Torone in Eubœa, but also in Syria and Cilicia; yet there the fruit was not ripe, probably because the plants, when

brought there, were not in their natural situation. The plant has disappeared in Egypt, but few specimens of it are found in Syria, Cilicia, and Greece; but *Nymphæa lotus*, of which the ancients likewise make mention, still grows there. Egypt has lost several animals and many plants.

Nelumbium speciosum is the holy *padma* of the Indians, the celebrated lotos flower, the fruit and root of which are eaten; a plant with which the mythology of that people delights to sport. With them the bean is as it was with the ancients, especially the Romans. The prohibition to eat beans, which is ascribed to Pythagoras, is derived from the Indians. Gellius ascribes the well known verse, in which the eating of beans is forbidden, to Empedocles, and says, Empedocles, *non a fabulo edendo, sed a rei venereæ proluvio voluisse homines deducere*, (Noct. Attic. l. iv. c. 11.) The Geoponicæ mentions it as a verse of Orpheus. There is no doubt that this prohibition was derived from the ancient Egyptians, as is distinctly stated by Herodotus, (l. ii. c. 37.); and that it was ascribed to all those who disseminated the ancient Egyptian learning. Originally this prohibition might have come from India, founded on the holy *padma*, and applied by the northern nations to a fruit which served them as its substitute. The lively *padma* was an image of procreative nature, because the embryo lies completely undeveloped in the nut. The imagination of the ancients saw in the embryo of our bean, a resemblance to the human members, as Theophrastus says, (Hist. Pl. l. viii. c. 2.) Among the Romans, whose language and customs were more nearly related to the Indian than to the Greek, the bean was a holy fruit, as was evinced by the *fabaria* dedicated to the *Carna Dea*, by the black beans, with which the Lemures were expelled, and by the *Faba referiva*, which was brought back from the seed that had been sowed, that something might be returned. The bean is widely dispersed; it is cultivated every where in Europe, and in Asia as far as the north of India and China; and from the most ancient times, if we may trust the *Memoir. s. l. Chinois*. In the Arabic, it has a name which is not now in use, باقلي, instead of which, the term فول is now used.

Lentil, Ervum Lens.

After the bean, our attention may now be directed to the *Lentil*, (*Ervum lens*, *Vicia lens*,) since Columella has treated of them in this order. Beside the large and small lentil, which are but varieties, the black lentil (*Lens nigra*), with short, two-seeded pods, small, flat, sharp-margined, entirely black seeds, seems to be a different species, as is also perhaps the brown-spotted lentil (*Lens punctata*), with short pods, often containing but one seed, and pretty large, roundish, fine brown-spotted seeds: But this last is less remote from the common species. The lentil grows wild among the corn in Germany, Switzerland and France. The marks of this species have been already given. Sibthorp says, (Prodr. Fl. Græc.) *quandoque etiam sponte inter segetes provenit magnitudine minor et cirrhis fere orbata*;—a description which is very probable. The Greek φακὸς is our lentil; the descriptions given of it do not disagree with this supposition; and at this day the lentil is called in Greece φακῆ. Formerly φακῆ was the name given by Galen to the lentil when taken from the pod and dressed. In the Geoponica, (l. ii. c. 37.), the fruit is called φακῆ, and the plant φακὸς. The stem rises obliquely (πλαγιόκαυλος, Theophr. Hist. Pl. l. viii. c. 3.) Theophrastus says this of all plants which have tendrils, but are yet able to support themselves without them. The pods are flat, (c. 5.) Φακὸς is always translated by *lens* or *lenticular* among the Romans. According to Columella, the lentil is sown twice a-year; early, that is in autumn, or late, that is in February. The meal of lentils is much used as a medicine. Pliny mentions an Egyptian lentil, rounder and blacker than the common (l. xviii. c. 12.); and Theophrastus speaks (Hist. Pl. l. iv. c. 5.) of Indian lentils, resembling *Fœnum Græcum*. From this resemblance I cannot consider them as the *Dolichos catjang*, as Sprengel does, (Hist. Rei Herbar. i. p. 80.) Under the Arabian name عد ص the lentil is cultivated in the east throughout Cabul, as far as the north of India; and in Hindostan it is called *maschuri*. It is certainly a native of a temperate climate, such as the temperate parts of Europe.

Peas.

Respecting *Pease,* we are late of finding any information among the ancients. Yellow pease are not mentioned, as is supposed, by Aristophanes, but he is speaking (Plut. v. 427.) only of a λεκιθοπῶλις. The Scholiast says, λέκιθον means an egg, and that the former word signifies a buyer of eggs. But λέκιθον also signifies *πίσον,* and this has its name from Pisa in Elis. What Theophrastus has said of *πισὸς,* does not correspond with our pease. He places them, indeed, among the *χέδροπα,* (Hist. Pl. l. viii. c. 1.); but he says, some have round leaves like beans, others long leaves, as *πισὸς, λάθυρος, ὦχρος,* (l. viii. c. 3.), whilst our pease have very round leaves. Commonly he places πισὸς along with λάθυρος and ὦχρος, (l. viii. c. 3., l. iii. c. 27.). He says further, πισὸς has many leaves, is divided at the root into many branches, suffers much from the cold, on account of its tender roots, is easily broken, and occupies a great space, (De Caus. l. iii. c. 15.). All this agrees better with a plant related to *Lathyrus sativus* than with our pea, which has not many leaves, nor many branches at the root, and is a hardy plant. From the Roman writers little that is definite can be gained. *Pisum* belongs, according to Columella, to the leguminous fruits which are used as food, likes a soft, light earth, and a warm, moist air, (l. ii. c. 7. 10.), and manures the ground when it is fresh cut, (c. 11.) Dioscorides does not use the word πισὸς. Galen (De Alimentor facultat. l. i. c. 11.) says little about it, and places it along with the bean. In the Geoponica (l. ii. c. 13. 3.), according to Columella's authority, it is said to prefer a loamy soil. Pliny (l. xviii. c. 12.) says, *Pisum impatientissimum frigoris,* and affirms that it has *siliquæ cylindraceæ,* from which expression, however, there is reason to fear that he was thinking on *κυλινδρώδεις ὀρόβου λοβοί,* (Theophr. Hist. Pl. l. viii. c. 5.) It is further said respecting *cicercula,—Est minuti ciceris inæqualis angulosi veluti pisum,* according to which the grain ought to be angular. It is further worthy of remark, that the ancient Arabians were not acquainted with our pease. They translated *pisum* by ماش; and in a manuscript of Ebn Baithar's *Materia Medica,* which lies before me, I find the following description of it. Masch is a small grain like *Ervum,* of a green colour, shining, with a navel spot

like that of the French bean, black and white: the leaf is also like that of the French bean, as is also the pod. In the East they are cultivated in the gardens, and are eaten. They grow in the southern regions: in Yemen, they are also called Short-pods, (Hülse, قطن). They have a good taste. After that follows a translation of what Galen says respecting πισὸς. It thus appears, that Ebn Baithar speaks of a *dolichos* or *phaseolus*, and not of our pea. From all this it is evident to me, that our pease were altogether unknown to the ancients, and that their πισὸς or *pisum* belonged to the *Lathyrus*. Hence we see the reason of the uncertainties of the modern tongues. The German word *Erbse* comes from *orobus*; the *ervilla* and *ervilha* of the Spaniards and Portugueze from *ervum*; the *pois* and *pisello* of the French and Italians from *pisum*. In the new Greek dialect pease are called αυκὸς, by a quite new name; and in the same manner we have *gorochi* in the Russian dialect. Pease belong to northern countries, and are cultivated throughout the whole of Europe, and in Asia as far as China, and northern India. According to later botanists, the pea grows wild in the fields of Europe, with which account what I have already said corresponds.

Phaselus.

The notices which the ancients have left us respecting *Phaselus* or *Phasiolus* are few. Theophrastus and the ancient Greeks do not mention it. Columella says, (l. ii. c. 20.) *phaselus* must be sown early in harvest, in a rich soil, four *modii* on an *jugerum*; the seed also is smaller than that of field beans, and resembles the grains of πισὸς and λάθυρος. He places them among the leguminous fruits which are eaten by man. Dioscorides (l. ii. c. 130.) speaks only of their medicinal properties. Pliny says, (l. xviii. c. 12.) the grains are eat along with the pod. This agrees exactly with our French beans. But from Galen's information, (De Alimentor facult. l. ii. c. 25, 28.) we see what mistakes have prevailed respecting the names of the leguminous fruits. He mentions φασῆλος along with ὦχρος the small *lathyrus* as a bad fruit; and then says, some consider φασῆλος and λάθυρος as the same; some regard it as a variety of the latter; some distinguish between φασίολος and φασῆλος, and give the former name to the French bean (δόλιχος). There is also no

doubt that the words *phaselus* and *pisum* were first used to denote varieties or species of the *lathyrus*, and that afterwards they were appropriated to other leguminous fruits; the former very early to the French bean, and the latter at a more recent period to pease.

Dolichos.

Dolichos in Theophrastus (Hist. Pl. l. viii. c. 10.) seems to be our French bean, for Theophrastus says it bears good fruit when it is permitted to climb, but bad when it lies upon the ground. Galen, (De Aliment. facultat. l. i. c. 28.) quotes the passage, and applies it to a fruit which, in his time, was called short λοβὸς, *silique*. The putting of φασῆλος along with ὦχρος, and πισος in the book of Hippocrates *De Diæta*, induces Galen to think, since λάθυρος and φασῆλος are not mentioned, that δόλιχος belongs to the same arrangement. He also appeals to a passage in Diocles Karystios, where κύαμος, πισὸς, δόλιχος are mentioned, but not λάθυρος; and adds, we may believe that λάθυρος, ὦχρος, φασῆλος are the same plant. To this list δόλιχος ought to have been added. He further concludes, that the δόλιχος of Diocles is the plant which is reared in gardens, and the pods of which are eaten green. Dioscorides describes under the name of σμίλαξ κηπαῖος our French bean very distinctly, (l. ii. c. 176.) The Arabians understood this, and Eben Baithar quotes, under the French bean, the σμίλαξ of Dioscorides. The French beans, that is to say, the large French beans, but not the creeping beans, were well known to the ancients, and were denoted by the words δόλιχος and φασῆλος, which, at a more early period, had been appropriated to *Lathyrus*. The native country of the common French bean *(Phaseolus vulgaris)*, as well as of the creeping bean *(Phaseolus nanus)* is India, that is extremely probable, since these plants cannot endure the slightest frost. In the catalogues of plants cultivated in India, I find, indeed, *Ph. max.* and *mungo*, but not our French bean, and correct information respecting its occurrence in India is entirely wanting. Willdenow asks, whether the Turkish bean *(Ph. multiflorus)* be a native of America, induced, doubtless, by a notice in the botanical work of Houttuy; namely, that the Admiral Peter

Heim first brought this plant from Brazil. But in the old botanical works respecting Brazil, I find no notice of it.

The Chick Pea, (Cicer arietinum.)

The *Chick pea (Cicer arietinum)* is found, like the lentil, growing wild in the corn fields of southern Europe; but it is only found occasionally, and by accident in them. It is, without doubt, the ἐρέβινθος of the Greeks. It is a leguminous fruit (Theophr. Hist. Pl. l. viii. c. 1.), with a deep seated root (c. ii.), πλαγιοκαυλον (c. iii.), with a round pod (c. v.) It is twice sowed in a year. The Greeks still call it ῥέβιθι. It is mentioned in the Iliad, immediately after the above cited passage, respecting lentils. There were, as now, many varieties of the fruit, black, white and red, (Theophr. Hist. Pl. l. viii. c. 6.) The name ἐρέβινθος denotes only the chick pea. The Romans always translated ἐρέβινθος by *cicer*, and cultivated this fruit very much, as is still the case in the south of Europe. Chick pease are still called *ceci* in Italy, *pois chiches* in France, *kichern* in Germany; all of which names come from *cicer*. In Spain and Portugal, they are called by a moorish name *garavanzos*. A variety was called by the ancient Greeks κριός, in Latin *arietinum*, from its resemblance to the head of a ram. The ancients also speak often of the acid which chick pease perspire, and which has lately given occasion to many chemical experiments, (S. Scherer's Journ. für Chem. Th. viii. s. 272). They call it ἅλμη or *salsugo*, and maintain that it is peculiar to the chick pea, and does not injure its growth. Chick pease are cultivated throughout the whole of southern Europe, in the East, in Kabul *(mickhod)*, and in northern India *(But)*. They require such a climate as the south of Europe. Dioscorides mentions wild chick pease (l. ii. c. 126.), as does also Pliny (l. ii. c. 25.), but the former mentions that they are different in regard to the fruit, and are therefore certainly a different species. *Cicer punicum*, (Columb. l. ii. c. 10, 20.), I regard as rather a variety of the chick pea, than *Lathyrus sativus*.

Lupin.

Every thing relating to the *Lupin (Lupinus albus)* is equally clear. It is the *lupinus* of the Romans, θέρμος of the Greeks, a plant which is cultivated throughout the whole south of Eu-

rope. It has a very distinct property, which is also noticed by the ancients; namely, the bitterness of the seeds, which makes them quite inedible, unless they have been steeped in water, before being cooked, and their bitterness extracted. The *Lupinus albus* alone is cultivated in the south of Europe, on account of its edible fruit. The *Lupinus termis*, according to Forskal, is cultivated in Egypt. The Arabians have retained the Greek name in their language. *L. angustifolius* is cultivated at Bourdeaux as fodder. There are many wild species of Lupinus in the south of Europe, *L. varius*, *pelosus*, *luteus*, *angustifolius*, *hirsutus*; but it is very remarkable how completely the regular and numerous growth of these wild species in the corn fields is distinguished from the solitary and rare appearance of *L. albus*.

Lathyrus Sativus.

In the south of Europe, the *Lathyrus sativus* is frequently cultivated, and commonly the variety with white flowers; those with blue flowers came first from Egypt, according to Clusius. Formerly this plant was more cultivated than at present, as we learn from the ancient books of plants. Its use has been at different times reckoned hurtful; and at last it has been believed that lameness may arise from eating its meal mixed with bread. It is considered to have been the λάθυρος of the ancients; and Theophrastus's notices agree with this idea. It has long leaves, and lies upon the ground like πισὸς, (Hist. Pl. l. viii. c. 3.) The modern Greeks also call it λάθυρι. Theophrastus always places λάθυρος and ὦχρος together. Both of them are translated, sometimes by *cicera*, sometimes by *cicercula*; ὦχρος also is translated by *ervilia*. The translation of ὦχρος by *Pisum ochrus*, is without any foundation. Λάθυρος and ὦχρος are certainly not very different, and so also are *cicera* and *cicercula*. Columella says of *cicera* (l. ii. c. 11.), *Hominibus non inutilis nec injucunda, sapore certe nil differt a cicercula, colore discernitur, est obsoletior et nigro propior.* As *L. sativus* has angular, and *L. cicera* round seeds, the *cicercula* of the ancients is probably not *L. cicera*, otherwise Columella would certainly have noticed that distinction, and not the mere colour. We thus come to the conclusion, that πισὸς, λάθυρος, ὦχρος, *pisum*, *cicera*, *ci-*

cercula are varieties. In Italy *L. sativus* is called *cicerchia;* in France it was formerly called *sars*, at present *gesse*, or *pois de brebis;* in Spain and Portugal *chicharo.* It is cultivated as far as the north of India, and the Sanskrit name is *kesari*, which is wonderfully like the word *cicera.* It thrives in a climate like that of the south of Europe, and is found, like lentils and other similar plants, growing wild in the fields. Dioscorides, who passes by no kitchen vegetable, no edible fruit, does not use λάθυρος, πισὸς, ὦχρος, but only φασιόλος, a name which, according to Galen, agrees with ὦχρος, which also shews the small difference between these names. *Lathyrus cicera* is at present cultivated as fodder in some of the districts of France.

Aphaca.

Aphaca is mentioned by Theophrastus, (Hist. Pl. I. viii. c. 1.) It ought to be sowed late: the pods are broad as in the lentil; it has a resemblance to the human members, like the bean, (c. 2.) Dioscorides describes (l. ii. c. 177.) *aphaca* as a plant taller than the lentil, with small leaves, with pods larger than those of the lentil, in which from three to four seeds are found. *Aphaca* is not to be confounded with *Lathyrus*, as is easily understood, since this last has round leaves. The Romans do not mention *Aphaca*, only Pliny speaks of it as a wild plant, (l. xxi. c. 13.); he also uses the words *Amara aphace*, (c. 17.) Instead of it the Romans speak only of *Vicia*, but not the Greeks, except the later Greeks, who have admitted the word βίκια. Columella speaks of the cultivation of vetches, (l. ii. c. 11.) and there is nothing which should prevent us from believing that the *Vicia* of the Romans is our *Vicia sativa.* The name *Vicia* has also passed into all languages. But how was *Vicia* named among the older Greeks? The Arabians seem to be correct in translating *aphaca* by Vicia: the descriptions of the Greeks also agree extremely well with our vetch, and Galen uses both names, yet he does not speak distinctly respecting their agreement. The native country of the vetch is uncertain. Of the garden vegetable *Aphaca*, we shall speak by and bye.

Ervum of the Romans.

Ὄροβος of the Greeks, *ervum* of the Romans, is, as is generally supposed, *Ervum ervilia.* It has a mark which points it out, namely, its stupifying property. Of this property Theophrastus, Columella and others, make mention. It is believed that this property depends upon the time at which the grain was sown. The plant actally grows wild in the south of Europe. The modern Greeks call the fruit ὄροβος *ervum* has passed into most of the other modern dialects; the Italians call it *veggiola.*

Trigonella Fœnum Græcum was much cultivated by the ancients, and is still cultivated, especially for fodder. The seeds were very much used by the ancients as medicine. They also made use of their mucilage. According to Galen, the green plant was eaten. In Theophrastus's writings only βούκερας is mentioned among the later Greeks, the plants is called τῆλις; Galen says there is no difference between them, and adds also the name αἰγόκερας. The Romans cultivated the plant under the name *Fœnum Græcum,* which has passed into all modern languages. The Arabians also valued the plant greatly as a medicine. It seems to grow wild in the south of Europe.

Ἄρακος is quoted by Galen as another name of *Lathyrus,* which appears in a play of Aristotle that has not been preserved. In Theophrastus (Hist. Pl. l. viii. c. 8.) there is mention of a weed of this name. Galen speaks of a weed called ἄραχος, which, without doubt, is the same. Sprengel supposes the former to be *Pisum arvense,* the latter *Ervum tetraspermum* or *Vicia lathyroides.* The latter does not appear in the south of Europe as a weed, and with respect to the two former, we may as well suppose another species of *Lathyrus* or *Vicia.* It is equally uncertain what ἀραχίδνη means in Theophrastus (l. i. c. 11. c. 6. ed. Schneid.) The plant brings forth its fruit under the ground, whence Sprengel supposes it to be *Lathyrus amphicarpos,* in the History of Botany; and *Arachis hypogæa,* in the Herbar. Botanic. But, according to Theophrastus, the plant has no leaves, not even any thing resembling them, and all known plants have leaves.

Art. XIX.—*On the Geographical distribution of Insects* *. By M. Latreille.

ONE of the most curious subjects in Entomology, and which has not hitherto been treated of, the determination of the climates proper to the different tribes of insects, is nearly connected with the history of their nutrition. For, in fact, since the Author of Nature has spread living beings over all the points of the surface of our globe, capable of maintaining them, and since these beings vary with the climates, it is necessary that the alimentary substances of animals should vary equally; and thus, as well as the animals themselves, should have a geographical circumscription.

Independently of such consideration, the temperature which fits the developement of one species, is not always proper for that of another; thus, the extent of country which certain species occupy, has necessarily determinate limits which they cannot exceed, at least suddenly, without ceasing to exist.

These principles lead to another consequence; where the empire of Flora terminates, there also the dominion of animal life is at an end. The animals which maintain themselves on vegetables, cannot live in places entirely steril; and those which are carnivorous, would be equally deprived of alimentary matter, in the absence of those creatures of which they make their prey; therefore, neither tribe can be there established.

The observation teaches us, that the countries the most abundant in animals with articulated feet, more especially insects, are those of which the vegetation is the richest and the most rapidly renewed. Such are the effects of a warmth strong and long sustained, of a moderate moisture, and a varied soil. The nearer, on the contrary, that one approaches the limit where snow and ice are eternal, whether by advancing towards the Poles, or by ascending mountains, the more is the number of plants and insects diminished. Thus, Otho Fabricius, who published a

* Abridged from the "*Introduction à la Geographie Générale des Arachnides et des Insectes, ou des Climats propres à ces animaux.*" *Mémoires du Muséum d'Histoire Naturelle*, vol. iii.

good Fauna of Greenland, makes mention of only 468 species of animals, and the number of insects, including under that class, after the manner of Linnæus, both the crustaceous animals and the Arachnides, merely amounts to 110*. Lastly, as one approaches those regions where winter rules without ceasing, all living things disappear, and Nature no longer possesses the power of production. The plains which border on the Polar Regions, are found in that respect, to be in the same state of inertia as those parts where the region of perpetual congelation commences among the mountains of the torrid zone, or on those of the most fruitful countries. These mountains, considered in relation to the vegetables and animals which are proper to them, form gradually, and, by superposition, particular climates, of which the temperature and the productions are similar to those of plains in more northern countries. It is thus that the Alps are the habitation of many insects which are not found elsewhere, except in the north of Europe.

The insect called *Prionus depsarius*, which appeared till now to have no other country than Sweden, has lately been discovered among the mountains of Switzerland. I have myself taken at Cantal the *Lycus minutus*, supposed to have been confined to the most northern provinces of Europe. Thus, also, that beautiful insect called by Linnæus the Apollo Butterfly, so common among the fields and gardens in the neighbourhood of Upsal, as well as in other parts of Sweden, does not live in France, except on mountains, the elevation of which is at least 600 or 700 toises above the level of the sea. The *Carabus auratus* †, the *Acrydium grossum*, many of our butterflies, the common viper, (*Coluber berus*), &c. living here (the latitude of Paris) in the plains, or on very slight elevations, have, in the south of France and Italy, their domicil on alpine or subalpine mountains. There these animals find a similar temperature, and the same nutritive substances. The intelligent entomologist will always take into

* It is possible that this author has mentioned only the more remarkable species, and has not intended to give a complete entomology of the part of Greenland of which he studied the productions. But one is, nevertheless, authorised in concluding, that the number is there very limited.

† The proper Carabi have their principal seat in the temperate zones, rather approaching the north, or elevated situations, than the south. They occur in Spain and Barbary ; but there the species are few in number.

consideration the height above the sea of the places where he collects his specimens, and he will also observe with care the mean temperature.

Naturalists, as well as geographers, have divided the surface of the earth into different climates. The latter have taken for a base the progressive differences in the longest duration of the natural day; the former have founded their divisions on the mean temperature of the regions proper to animals and vegetables. In the *Philosophia Entomologica* of Fabricius, the acceptation of the word Climate is general, and embraces the universality of the habitations of insects, or of all the animals with articulated feet. He divides climate into eight stations, or particular subclimates, viz. The *Indian*, the *austral*, the *Mediterranean*, the *northern*, the *eastern*, the *western*, and the *alpine*. But it is easy to see, by the enumeration of the countries which belong to each of them, that these divisions are not always established on positive documents, and that it would be necessary, if one follows rigorously the principle on which they rest, the mean temperature, that some of them be suppressed. The subclimate which is called *Mediterranean*, comprehends the countries adjacent to the Mediterranean Sea, and also Media and Armenia. The *boreal*, or northern, extends from Paris to Lapland. The *eastern* is composed of the north of Asia, of Siberia, and of the cold and mountainous part of Syria. The western includes Canada, the United States, Japan, and China. This simple *exposé* may suffice to convince us, that there is much that is arbitrary in these divisions. Several of these countries actually have the same mean temperature; yet they are not ranged under the same climate. But besides that these distinctions are scarcely of any use to science, since the places in which the mean temperature is the same, produce different animals, it is impossible, in the actual state of our knowledge, to insure such divisions of climate on a solid basis. The different elevations of the soil above the level of the sea, its mineralogical composition, the variable quantity of water which moistens it, the modifications which the mountains, by their extent, their height, and their direction, produce on its temperature, the forests more or less great by which it is covered, the influence exercised on its temperature by that of neighbouring climates,—are the elements which render complicate these calculations, and which

throw over them so much uncertainty, considering the difficulty which there is in appreciating the importance of the modifying circumstances, whether single or combined.

I shall consider the climates under another point of view, that which is offered us by the *genera* of Arachnides * and of Insects, peculiar to determinate spaces on the surface of the earth. Our catalogues relating to exotic *species*, are too imperfect to admit of our following another plan; for even the European entomology may be said to be nothing more than sketched †. But, even supposing that we had not to plead this penury of materials, I would not fatigue, by the wearisome enumeration of species, and by all the little details into which the subject would conduct us. Would it not be necessary always to fix one's attention on some general ideas, and on the most important results? Such is the end which I have proposed to myself; and although, with more assistance, I might have succeeded better, I trust, however, that a good use of the feeble means which my studies have furnished me, will lead to new views which I believe worthy of interest. For the rest, I may be said to open a new path, or rather to mark out its traces, and my efforts, even though fruitless, may at least merit some indulgence.

Many of our travelling naturalists may be reproached with negligence in regard to their indication of the precise places where they collected the objects which enrich our museums. This first fault committed, one need not be surprised that they have not remarked the particular qualities of the soil, considered physically, and under its mineralogical aspects. Yet these details form an essential part of the history of animals. The genus *Licinus*, the *Papilio cleopatra*, many of the genus *Dasytes*, (*Dermestes*, Lin.) some species of *Lamia*, &c. are only found on calcareous soils. I have observed that the *Pimelia bipunctuata*, very common in the environs of Marseilles, scarcely extends to the sea-coast. If the interior of lands in Bar-

* The class Arachnides consists of the genera *Aranea*, *Scorpio*, *Acarus*, &c. recently removed from the *Insecta*. They are remarkable for the want of antennæ, and distinguishable from the true insects by other important characters.

† Even with all the talents of M. de Humboldt, it would be impossible to do for the geography of Insects, that which he has executed for the geography of Plants.

bary, in Syria, in Egypt, &c. presents other species of the same genus, it is because the soil is there impregnated with saline particles, or abounds with plants of the salt-wort kind, *Salsosa*; thus these pimeliæ always inhabit an analogous soil. The insects of the countries which border the Mediterranean, the Black, and the Caspian Seas, bear a great relation to each other, and for the most part abide on the ground, or on plants little elevated. Those countries seem to be the principal seat of the second section of Coleoptera (the *hétéromères*,) and of the genera *Lixus*, *Brachycerus*, *Buprestis*, (the conical formed species,) &c.; and although the Cape of Good Hope is so far distant, yet many of its insects bear the features of a family resemblance with those just mentioned. From this fact we may draw the inference, that the soil and the vegetable productions of these different countries possess many characters of a natural affinity.

It is easy to see that the same care should be observed in the local observation, as well of the species which live in water, of which it is necessary to distinguish the nature, as of those which reside along the shores. All such accessory knowledge may throw light upon the particular habits of these animals, or give rise to reasonable presumptions. Having thus called the attention of travelling naturalists, and presented some preliminary observations, I come directly to my subject.

The following propositions are established on the study which I have made of one of the most beautiful museums of Europe, of the private collections of Paris, and on the information which I have acquired, as well from published works as by my own researches, and a widely extended correspondence.

1. The whole, or a very great proportion of the Arachnides and Insects, which have for their birth-place countries of which the temperature and soil are the same, but separated by a great space, is composed in general of different species, even though such countries may lie under the same parallel. All the Insects and Arachnides which have been collected in the most eastern parts of Asia, such as China, are distinct from those of Europe and Africa, whatever may be the latitude and temperature of these Asiatic countries.

2. The greater number of the above-named classes of animals, differ from each other specifically, when the countries in

which they make their abode are separated from each other by natural barriers, either entirely interrupting, or rendering very difficult the communication, such as seas, chains of highly elevated mountains, vast deserts, &c. Thus the Arachnides, the Insects, even the Reptiles of America and of New Holland, cannot be confounded with the animals of the same classes, which inhabit the ancient Continent. The insects of the United States, although often nearly allied to ours, are yet separated by certain characters. Those of the kingdom of New Granada and of Peru, countries so near to Guiana, and equally equinoctial, differ nevertheless, in a great part, from those of the latter country, their climates being divided by the Cordilleras. When one passes from Piedmont into France by the Col de Tende, a manifest change may be observed. These rules suffer some exceptions in regard to aquatic species. There are also certain insects of which the distribution is very widely extended. *La Belle Dame*, or Painted Lady Butterfly, (*P. cardui*), so common in our climate, and even in Sweden, occurs at the Cape of Good Hope, and New Holland presents a species almost entirely the same. The *Sphinx du Nerion*, and the *Sphinx celerio* or Silver-striped Hawkmoth, have our own climate for their northern limit, and for their southern the Isle of France. Amongst aquatic insects, the *Dytiscus griseus*, which lives in the waters of Provence and of Piedmont, is not unknown in Bengal. I do not speak from authors, who often confound the species of far distant countries, when they have some characters in common, but from my own observations *.

* Although the animals of the class *Crustacea* do not belong to my present subject, I may add the following general observations:

1. The genera *Lithodes*, *Corystes*, *Galathea*, *Homola*, *Phronyma*, are proper to the seas of Europe.

2. Those of *Hepatus* and *Hippa* have not yet been found, except in the American Ocean.

3. From the same, and the coasts of China and the Moluccas, comes the genus *Limulus*.

4. The genera *Dorippe* and *Leucosia*, inhabit particularly the Mediterranean and the seas of the East Indies.

5. The last named seas give us exclusively the following genera: *Orythia*, *Matuta*, *Ranina*, *Albunca*, and *Thalassina*.

6. The other genera are common to all the seas; but that of *Ocypode* is only found in warm countries. The great species of *Grapsus* come from South America and New Holland.

3. Many *genera* of insects, and particularly those which feed on vegetables, are spread over a great number of points in the principal divisions of the globe.

4. Some others are exclusively proper to a certain extent of country, whether of the ancient or the new Continent. The following genera are never found in the latter country; *Anthia, Graphypterus, Erodius, Pimelia, Scaurus, Cossyphus, Mylabris, Brachycerus, Nemoptera, Abeille (Apis of Lat.), Anthophora,* as well as many others of the family *Scarabéides*, &c.; on the other hand, the western hemisphere presents us with many genera, which are not to be met with elsewhere, and of which the following are the principal: *Agra, Galerita, Nilio, Tetraonyx, Rutelia, Doryphora, Alurnus, Erotylus, Cupes, Corydalis, Labidus, Pelecinus, Centris, Euglossa, Heliconius, Erycina, Castnia,* &c. our bees are there replaced by the genera *Milipona* and *Trigona*. The genera *Manticora, Graphiptera, Pneumora, Masaris,* &c. have hitherto been found only in Africa; the first and the third of these genera are even restricted to the Cape of Good Hope. The *Colliuris* is proper to the East Indies. The genera *Lamprima, Heleus, Paropsis,* and *Panops,* come only from New Holland, and some neighbouring islands *.

5. Many species, in their native country, affect exclusively certain localities, whether in low lying districts, or in those which are elevated to a fixed height. Certain alpine butterflies are always confined near the region of perpetual snow. When a traveller ascends among mountains to a height at which the temperature, the vegetation, the soil, are the same as those of a country much more northern, he there discovers many species which are characteristic of the boreal regions, and for which he would search in vain among the plains and valleys at the foot of these mountains. I have already cited some examples, which support this rule. If, in the same country, the temperature of certain low lying spots is modified by local circumstances, we there also find many species which occur more frequently a little further north, if the mean temperature has been lowered, or a little further south, if it has been raised. It is thus that we begin to observe to the north of the department of the Seine

* The largest species of *Cossus, Zeuzera* and *Hepiades* come from these countries.

insects proper to colder districts, to Germany, &c. and that the warm and sandy soils, situated to the south and east of Paris, present some species belonging to more southern regions.

6. We shall divide the Old and New Continent into zones, spreading successively in the manner of meridians, and of which the breadth is measured by a portion of a circle parallel to the Equator. The species proper to one of these zones disappear gradually, and give place to those of the following one; so that from one space to another, the prevailing species, or even the totality undergo a change. I compare these changes to that series of horizons which the traveller discovers, in proportion as he removes from his first point of departure.

Sweden has many species of insects which are particular to it, and of which some are banished to its most northern provinces, such as Lapland. But its southern district, for example, Scania, offers, though in small quantities, many insects of Germany. France, as far as the 45° or 44° of latitude, produces many species also found in these countries. It appears that the Rhine and its eastern mountains, form, in regard to some other species, a sort of frontier which they have not crossed. The first of those which are proper to the warm countries of western Europe, shew themselves towards the inferior course of the Seine, precisely at the point where the vine begins to flourish in the plains, without the assistance of local circumstances. The *Ateuchus flagellatus*, the *Mylabris chicorii*, the *Mantis religiosa*, the *Ascalaphus italicus*, &c. announce this change. It is still more manifest at Fontainebleau, and the environs of Orleans, where, besides those just mentioned, we find the following species: *Phasma Rossii*, *Mantis pagana*, and *Sphinx celerio*, &c.

But these insects, if I may so express myself, are only the forerunners of such as are proper to the truly southern countries. One recognises the domain of these last, on the appearance of some other species of *Cicada*, *Mantis*, *Zonitis*, *Akis*, *Scaurus*, *Termes*, &c., but more especially in the presence of the *Scorpio Europæus*, and the *Ateuchus sacer* *. The cul-

* The butterflies of the division called *Equites* or Knights, have also their principal seat in warm countries, and especially between the Tropics. Those which Linnæus has named *Trojans*, are proper to America, and that part of Asia which lies beyond India.

ture of the Olive, the spontaneous growth of the Strawberry tree, the Pomegranate tree, and the Lavender, speak still more plainly to the eye. This change is very perceptible, when, in going from Paris to Marseilles, one reaches the territory of Montelimart. The borders of the Mediterranean are a little warmer; and species belonging to the Genus *Mygale*, *Onitis*, *Cebrio*, *Brentus* and *Scarites*, appear there for the first time. If we penetrate into the interior of Spain, and visit its beautiful eastern provinces, where the orange and the palm are vigorous in the open air, a new assortment of species, intermingled with some already observed in the south of France, will command our attention. We may there observe species of the *Erodius*, *Sepidium*, *Zygia*, *Nemoptera*, *Galeodes*,, and many other insects analogous to those of Barbary and the Levant. The knowledge of these species having become familiar to us, the entomology of the Atlantic countries of Africa, or of those which are situated on the Mediterranean, as far as the Atlas, will not excite in us very great surprise. We shall there, however, discover certain genera of insects which have their centre of dominion in the regions comprised between the tropics; such as the Genus *Anthia*, *Graphipterus*, *Siagona*, &c.

We have only a very imperfect knowledge of the insects of the south-east of Europe. I shall merely remark that the *Papilio crysippus* of Linnæus, common in Egypt and the East Indies, appears already in the kingdom of Naples.

(*To be concluded in next Number.*)

Art. XX.—*On the Difference between the Land and Sea Rates of Chronometers, deduced from the Register kept on board his Majesty's Ship* Leven, *in two Voyages to the Cape de Verd Islands.* By Lieutenant Mudge, R. N.

FINDING, on my return from a recent voyage to the Cape de Verd Islands, that the attention of philosophers has been called to the subject of chronometers, and particularly to their change of rate on ship-board and on shore; and having, with Lieutenant Vidal, for nearly three years, kept the rate of the four chronometers appropriated to this vessel, under different

circumstances, I am willing to think, that the results will not be uninteresting to the readers of the Edinburgh Philosophical Journal, particularly as they give an undeniable proof that such a change actually takes place, and shew the necessity of some means, either of preventing it, or of estimating its amount.

TABLE of the Land and Sea Rates of the Chronometers, supplied to his Majesty's Ship LEVEN, *during her Voyage to the Cape de Verd Islands, in the year* 1819.

Particulars of the Times, Places, &c.	N° 1970, Arnold Rate.	N° 498, Arnold Rate.	N° 249, Harris and Hatton Rate.	N° 503, Arnold Rate.
SR * Lisbon from Jan. 2. to Jan. 28. 1819,	- -	*l* ‖ 3.7	*g* 2.86	*g* 7.74
SR St Jago from Feb. 8. to Feb. 14.	*l* 17.30	*l* 1.98	*g* 5.53	*g* 5.68
SR Island of Sal, Feb. 28. to Mar. 28.	*l* 16.27	*l* 1.25	*g* 6.83	*g* 7.29
SR Do. Mar. 28. to April 20.	*l* 16.99	*l* 0.99	*g* 6.82	*g* 9.8
SR Quail Island, Apr. 27. to May 4.	*l* 17.9	*g* 0.26	*g* 6.34	*g* 10.39
SR Do. Apr. 27. to May 12.	*l* 17.66	*g* 0.66	*g* 6.55	*g* 9.86
Mean ship rates from the above, -	*l* 16.95	*l* 1.47	*g* 6.52	*g* 8.47
LR † Madeira, June 20. to July 7.	*l* 14.88	*g* 1.27	*g* 2.00	*g* 13.62
LR Do. July 7. to July 17.	*l* 13.90	*g* 3.85	*g* 1.85	*g* 14.85
LR Do. July 17. to July 28.	*l* 13.72	*g* 2.83	*g* 3.64	*g* 13.82
LR Do. July 28. to Aug. 6.	*l* 14.4	*g* 2.73	*g* 2.84	*g* 13.51
LR Do. Aug. 6. to Aug. 24.	*l* 13.85	*g* 2.60	*g* 2.87	*g* 13.15
LR Do. Aug. 24. to Sept. 1.	*l* 14.23	*g* 2.76	*g* 2.26	*g* 12.90
LR Do. Sept. 1. to Sept. 13.	*l* 14.10	*g* 3.20	*g* 3.50	*g* 14.60
LR Do. Sept. 13. to Sept. 19.	*l* 14.10	*g* 3.50	*g* 3.50	*g* 14.60
Mean land rates from the above, -	*l* 14.17	*g* 2.69	*g* 2.75	*g* 13.80
Difference between the mean Land and Sea rates, - - -	2.78	3.22	3.77	5.33

Unfortunately, the maker's rates, with which these chronometers were measured, and those which they had on their return, are not found in the register.

N. B. It may be proper to observe, that the above land-rates were taken by Lieutenant Vidal and myself with an astronomical quadrant, at the house of the British Consul.

* ABBREVIATIONS.

† SR Ship Rate. ‡ LR Land Rate.

‖ *l* Losing Rate. § *g* Gaining Rate.

TABLE of the Land and Sea Rates of the Chronometers, supplied to his Majesty's Ship LEVEN, *in her Voyage to the Cape de Verd Islands, during the years* 1820 *and* 1821.

Particulars of the Times, Places, &c.		N° 1970, Arnold Rate.	N° 493, Arnold Rate.	N° 249, Harris and Hatton Rate.	N° 503, Arnold Rate.
LR By maker, April 8. 1820.	-	g ″5.00	g ″3.00	g ″9.60	g ″7.00
SR * Portsmouth, from	Ap. 8. to May 3.	g 1.29	g 1.85	g 9.08	g 5.83
LR † Portsmouth,	May 3. to May 6.	g 3.80	g 3.24	g 9.50	g 7.80
SR St Vincent,	July 28. to Aug. 8.	- -	g 0.81	g 7.50	g 6.70
LR Madeira,	Sept. 2. to Sept. 15.	*l* 0.8	g 0.80	g 3.80	g 8.5
LR Do.	Sept. 23. to Oct. 7.	*l* 0.9	g 0.60	g 3.50	g 3.50
SR Teneriffe,	Oct. 7. to Oct. 17.	*l* 0.82	- -	g 6.27	g 9.89
SR Do.	Oct. 17. to Nov. 1.	*l* 2.66	g 0.60	g 2.86	g 7.40
SR Mouth of the Ouro,	Nov. 20. to Nov. 29.	*l* 0.92	*l* 0.26	g 3.77	g 9.19
SR Quail Island,	Dec. 22. to Dec. 27.	*l* 0.90	g 1.02	g 6.42	g 11.22
SR Island of Sal,	Feb. 7. 1821. to Feb. 12.	g 0.68	g 1.58	g 7.38	g 12.80
SR Quail Island,	Feb. 21. to Feb. 27.	g 0.58	g 2.50	g 7.83	g 12.83
SR Goree,	Mar. 5. to Mar. 17.	g 0.15	g 2.18	g 6.91	g 12.41
SR Quail Island,	Mar. 27. to Apr. 14.	g 0.41	g 1.75	g 7.30	g 11.83
SR St Vincent,	April 29. to May 13.	g 0.21	g 1.80	g 7.51	g 13.87

The rates in this voyage are certainly not so great as in the preceding, and consequently we cannot draw from them the same satisfactory conclusions between the sea and land rates; although the first four lines indicate very clearly that a change had taken place; but the amount is not so well defined.

In the former voyage, the watches went remarkably well, and the distinction between the two rates is well defined and satisfactory.

* These sea rates were found by comparison of times, April 8. as delivered by the makers; and the mean Greenwich time by the Observatory clock at Portsmouth, May 3.

† These rates were determined by Dr Inman at the Portsmouth Observatory.

Art. XXI.—*On the Magnetic Influence of the Islands of St Mayo and the Great Salvage.* By Lieutenant W. Mudge, R. N.

In the course of the year 1819, while engaged with Lieutenant Vidal in surveying the Island of St Mayo, we found the hills on which we were carrying on our operations so strongly magnetic, that the needle belonging to the theodolite became wholly useless; the dip increasing so much, that the needle could not traverse, in consequence of one end of it being drawn down to the face of the instrument. In order, therefore, to obtain a magnetic bearing, the latter was obliged to be inclined at a very considerable angle; and even then the direction became so uncertain and variable at different stations, as to be entirely useless for the purposes of the survey.

I did not at this time make any farther observations; but in our recent voyage, I have been induced to examine a similar circumstance which we met with in the Island of the Great Salvage near Teneriffe, a little more minutely: the result of which will be better seen by the annexed delineation of the island, (See Plate XI.), in which I have marked the several stations used in the survey, and the bearing of the compass at each of them, from which it will be seen, that the extreme difference in the variation of the compass amounted to about 72°, although the two stations were less than a mile asunder.

The island is obviously of volcanic origin, and consists principally of a dark coloured black rock, the detached parts of which, as well as the whole, exhibit strong marks of fixed magnetic polarity; but it is remarkable, that a large fragment, weighing about 20 lb., which I brought away with me, has lost much of its power, although its effect on the compass is still strong, and its polarity well defined. Even the dust of the roads, and of the floors of the cottages, has the same character as the rock itself, and may be gathered up like steel filings by means of a bar magnet. I have brought with me a small sample of this dust, and have placed both specimens in the hands of Mr Barlow of the Royal Military Academy, Woolwich, at whose suggestion I have been induced to lay this and the pre-

ceding article before the public, and from whom I have received the following communication.

"Dear Sir, *August* 14. 1821.

"The observations you have made on the magnetic power of the islands of St Mayo and the Great Salvage, are, I think, highly curious, and should be made public, as it may draw the attention of other observers to similar cases, which are doubtless frequently to be met with in different parts of the globe. The following remarkable instance of a like action, at a considerable depth under water, I learned last year from Mr Duncan, master attendant in his Majesty's dock-yard Chatham.

"This gentleman, who has always paid great attention to the phenomena of the needle, informed me that, in the year 1791, while he commanded a vessel (the Beaver) belonging to the Hudson's Bay Company, and while he was in search of a north-west passage, he met with a very curious circumstance, the particulars of which I extracted from his log-book, and I sent you a verbatim copy of my notes on the subject.

"On the 18th of August 1791, in Lat. 61° 52′ N., Long. 92° 23′ W., being then about 20 leagues from land, with soundings from 60 to 65 fathoms, with blue mud, Mr Duncan found his azimuth compass (which he describes as an excellent instrument, by the senior Gilbert) suddenly affected in a very remarkable manner, the card refusing any fixed direction, revolving round as if it had lost entirely its magnetic virtue. He immediately ordered up all his other compasses (seven in number), which were all affected in the same way. He then stood off farther from the land, and soon after his compasses resumed their usual action. Mr Duncan had with him a dipping needle furnished by the Royal Society, and it appears that the dip by it varied in a very short time from 78° to 86°; the mean dip, by one series of observations, was 81° 40′, and by another, 83° 45′. All the above particulars, and several others, were noted by him at the time, and I extracted them from his log.

"Yours very truly, P. Barlow."

In the above statement relative to the survey of the Great Salvage, I have omitted to mention a very curious circumstance, which seems still farther to demonstrate the strong magnetic power of the island. The circumstance is this: when we

commenced our operations one morning, Mr Durnford, one of the party, laid down his watch at the first station, and, on our return to the same place again, we found that the watch had gained two hours in the interval, an acceleration doubtless due to the magnetic action of the rock upon the balance.

Art. XXII.—*Experiments and Observations on the Effects produced on the Rates of Chronometers, by the proximity of Iron Bodies.* By John Barlow, Esq. Royal Military Academy, Woolwich.

We slightly alluded to the above course of experiments in our last Number, stating, that Mr Barlow was still pursuing his observations, at the observatory of the Royal Military Academy, Woolwich.

This series has since been completed, and the results communicated to the Royal Society of London; and they will probably appear in an early number of the Philosophical Transactions.

That the ship and land rates of chronometers do not agree with each other, has been long noticed by navigators; but the change has generally been attributed to the motion of the vessel. Mr Fisher, however, in his voyage with Captain Buchan, found, that a very considerable change took place between his rates on board and on shore; although at the time of observation, the vessel was frozen into the ice, and was, consequently, as free from motion as his observatory on shore. He, therefore, very naturally attributed the change to the magnetic action of the iron of the vessel: and this appears to have suggested to Mr Barlow the course of experiments above referred to.

The apparatus employed on this occasion, was the same which that gentleman made use of in his magnetical experiments; the iron-ball being 13 inches in diameter, and weighing nearly 300 lbs. About this ball, at different distances, and in different situations, with reference to the magnetic equator or "plane of no attraction," he placed six excellent chronometers, taking their daily rates by transit observations, first at the observatory of his late colleague, the Reverend Mr Evans, and afterwards at the

Royal Military Academy, this removal having been rendered necessary, in consequence of Mr Evans retiring from Woolwich.

Each watch remained in its place three or four days, and was then removed to a different situation to the east, west, north and south; the direction in which each watch was placed, was also carefully observed; the twelve o'clock mark first pointing to the north, then to the east, west, &c., and a very considerable difference was observed accordingly; and as often as any previous situation was resumed, the watch was always found to return to the same rate; and the greatest care seems to have been taken to remove every thing of a magnetic nature from the place of observation, in order to be assured, that the effect produced should be due to the action of the iron only; and which, in his former experiments, Mr Barlow had ascertained to be perfectly free from any portion of fixed magnetism.

The effects produced, which, in some instances, amounted to about 5″ *per* day, must, therefore, be due to some magnetic property in the balance or spring of the chronometer; and to be satisfied on this point, Mr Frodsham, of the firm of Gaskinson and Frodsham, whose chronometers were so highly distinguished in the late voyage to the north, went down to Woolwich with detached balances and springs removed from chronometers, for the purpose of experimenting upon them; and the results perfectly satisfied both parties of the truth of the above conclusion. Perhaps the very nature and office of the balance-spring, is that which is the most likely to communicate to it a fixed polarity, and which, of course, will be immediately communicated to the balance, however free from such action those important parts of the machine may be, when first delivered from the hands of the maker. It being, then, almost impossible to prevent the acquisition of magnetism by the balance, it becomes important to estimate its effects; and hence the utility of such experiments as those above referred to, is sufficiently obvious.

In his former experiments, Mr Barlow made the singular discovery, that the power exerted by iron on the compass needle, *resided wholly on its surface*, and was independent of the mass; the same, it was easy to conceive, would be found to be the case with its action on chronometers, and a very few experiments

on a circular plate of iron twelve inches in diameter, fully confirmed the conjecture; such a plate, at the distance of about fifteen inches, producing a retardation, in one instance, of more than 4″ per day, and in another of about 3″.

In his former experiments, also, Mr Barlow suggested the idea of estimating, at all times, the effect of the guns, &c. on the compass, by introducing such a plate of iron as the above, in a situation where its power and effect should be equal to the combined actions of all the iron of the vessel; and we are happy to learn, by the return of H. M. S. Leven, that these experiments have, throughout the voyage of sixteen months, given the most satisfactory results. The same plan is now proposed by him for ascertaining the ship rates of the chronometers before they go on board, by simply taking their rates on a certain situation, and at a proper distance from such a plate of iron.

Should this experiment turn out equally satisfactory with the above, Mr Barlow will have had the good fortune, *first*, to have discovered a highly interesting scientific fact; and, *secondly*, to have found its immediate application to the removal of two of the most serious impediments to the perfection of practical navigation.

Art. XXIII.—*Proceedings of the Royal Society of Edinburgh.* (Continued from Vol. IV. p. 425.)

March 19. 1821. Dr Duncan *junior* read a paper "On the Distribution of the Muscular Fibres of the Ventricles of the Heart," illustrated by Casts and Drawings.

At the same meeting there was read "A Description of a New and Universal Balance," by Dr Dyce of Aberdeen. The instrument itself was exhibited to the Society.

A paper "On Electro-Magnetism," by Mr John Murray, Lecturer on Chemistry, was read.

April 2. The following Gentlemen were elected Ordinary Members of the Society:

Sir Charles Giesecke.	Robert Hamilton, M. D.
R. K. Greville, Esq.	

A paper by Dr Berry was read, entitled, "Observations on the Method of Sinking Wells at Madras."

Mr Thomas Allan read a paper "On the Formation of the Chalk Strata."

There was presented to the Society at this meeting, by the Most Noble the Marchioness of Huntly, a very magnificent specimen of Coral, from the Island of Bermuda. This specimen was of unusual magnitude, and is supposed to be the finest in the kingdom.

At the same meeting there was read a letter from Sir David Milne, Bart. to Professor Russell, giving an account of the method of fishing for large corals in the Island of Bermuda. They are found round the island in great abundance, in about three feet water at low tide. They are attached principally to the edge of the coral reefs, where the water deepens suddenly to 10 or 18 feet. They are fixed to the reefs by a kind of stalk, and seem of all sizes, from two inches to several feet in diameter, growing in clusters like mushrooms. When first taken out of the water they are of a light brown or snuff colour, but after a few weeks' exposure to the sun they become perfectly white.

A paper by Mr Marrat was read, entitled, "Observations on Terrestrial Refraction."

April 16. The first part of an Account of the Life and Writings of the late Dr Cullen was read, by Dr John Thomson.

April 30. Mr Henry Mackenzie read the concluding part of his Biographical Account of Mr Home, with Critical Remarks on the later Poets of Great Britain.

An account of a descent in the Diving-bell, by Dr L. T. F. Colladon of Geneva, was read. This paper is printed in this Volume, p. 8.

May 7. Dr John Thomson read a continuation of his Account of the Life and Writings of the late Dr Cullen.

At the same meeting there was read a notice by Mr John Ramage of Aberdeen, respecting a stickleback found with a leech in its intestines. The leech and the stickleback, which Mr Ramage had preserved, were presented, at his request, to the Museum of the Society.

There was also read a notice by Mr James Flint, civil-engineer, respecting large balls of clay ironstone in North America.

May 21. The Rev. Dr Somerville read a paper, entitled, " A Comparative View of the State of Society about seventy years ago, and at the present time."

June 4. The following Gentlemen were elected Ordinary Members of the Society:

Robert Allan, Esq.	Colonel Mair.
Honourable Lord Succoth.	A. N. Carson, Esq.
Sir David Milne, Bart.	Dr James Buchan.

A paper by Dr Henry Dewar was read, " On the Influence of Chemical Laws on the Phenomena of Physiology."

At the same meeting, there was read a paper by Benjamin Bell, Esq. ' On the combined action of the Salts of Copper, and of the Fixed Alkalies on Gelatine and Albumen."

June 18. A paper by Dr Francis Hamilton was read, entitled, " Notices regarding the Plants of various parts of India, and concerning the Sanscrita names of those regions."

At the same meeting, there was read a paper by Mr John Murray, " On Hydrocyanic Acid and Opium, in reference to their Counterpoisons." The following papers were laid on the table of the Society:

1. On the application of the Magnet to the Decomposition of Bodies, by Mr JOHN MURRAY.

2. Abstract of Experiments on various Optical subjects, by Dr BREWSTER.

The Society adjourned its Meetings till Monday, Nov. 5.

ART. XXIV.—SCIENTIFIC INTELLIGENCE.

I. NATURAL PHILOSOPHY.

ASTRONOMY.

1. *On the Phases of the Comet of* 1819.—M. Nicolas Cacciatore, Director of the Observatory at Palermo, announces that he observed very distinctly the appearance of phases in the nucleus of the comet of 1819, and hence he concludes that comets are not luminous *per se*, but that their nucleus, their coma, and their tail, shine only by reflected light.

2. *Notice respecting Venus.*—In September and October last, Venus was several times observed here, in open day-light, and also in part of the month of November, particularly on the 9th and 14th. The morning of the latter day being very fine and clear, I observed the planet perfectly distinct for a considerable time, when, by an exact observation, I found the sun's altitude to be 13° 44′: soon after this she was obstructed from further view by Cirro-cumulus. The planet was not to be found by the eye, but was immediately seen on looking towards the SW. Had the atmosphere continued clear, I have little doubt but she would have remained visible for one-half or two-thirds of an hour longer. Venus sheds the most splendour when about one-fourth of her disc is illuminated, when she is at her greatest north latitude, and when, at the same time, she is between her inferior conjunction and her greatest elongation. This concurrence, however, happens but once in about 7.93 years. At the time when the planet was so clearly seen here, 105 days had revolved since the inferior conjunction, and 36 since the greatest elongation had taken place; and her north latitude was about 1° 19′. As these positions are not considered the most favourable for day observations, I was induced to make the remarks I have just transcribed. Towards the close of October next, the planet will be upward of 41° to the west of the sun, and in this favourable position will, I have no doubt, be distinctly seen in the glare of open day, by the unassisted eye, particularly on her appulse to the meridian; for though, at the end of that month, her illuminated part will be about 8.785, her great western elongation will, at that season of the year, render her propitious for day observation. T. J.

Hill Top, near Wetherby, August 8. 1821.

OPTICS.

3. *On the Phosphorescence of Marine Animals.*—During a voyage to the Shetland and Orkney Islands, Dr MacCulloch had various opportunities of investigating the phenomena of marine luminous animals. In proceeding from the Mull of Cantyre to Shetland, and in almost all the harbours of Shetland and Orkney, Dr MacCulloch found the water filled with a species of animal which he considers to have been undescribed. A

cubic inch of water did not contain less than 100 of these animals. In the same view, and nearly at all times, the water was found filled with several different species, resembling in size some of the infusoria. Other animals of larger dimensions, and of many species, were equally constant, and, if less numerous, yet ten or twenty were always to be found within the space of a common tumbler glass. In all these cases the water was luminous. The light of the whole of these species disappeared when they died, either from keeping the water too long, from warming it, or from the addition of spirits. Dr MacCulloch has added upwards of 190 species to the list of luminous marine animals. The most conspicuous among these are about twenty small species of Medusa, in addition to those already known to be luminous. In the ancient genus Cancer, a considerable number of Squillæ were also found possessed of phosphorescence. In the genera Scolopendra and Nereis, five or six were luminous, which were all the species observed by Dr MacCulloch. The other known genera in which luminous species were observed, were Phalangium, Monoculus, Oniscus, Iulus, Vorticella, Cercaria, Vibrio; Volvox, to these Dr MacCulloch adds, among the fishes, a new species of Leptocephalus. The remaining luminous animals consisted of new genera, or at least of animals which could not be referred to any as yet to be found in authors. Dr MacCulloch seems to think, that the ling and other fish which inhabit the submarine valleys, at depths to which the light of day cannot penetrate, must perceive their food, and pursue their avocations, by the phosphorescence of their prey, or of the animals which abound in the sea, or by phosphorescence elicited from their own bodies. Dr MacCulloch's observations were generally made in harbours, but never at a distance exceeding eight or ten miles from land. See the *Journal of Science, Literature*, &c. vol. xi. p. 248.

4. *On the Phosphorescence of the Lampyris noctiluca and splendidula.*—In a curious paper on the Phosphorescence of the Lampyris *noctiluca* and *splendidula*, published in the *Bibliotheque Universelle* for May 1821, p. 52. M. Macaire has drawn the following conclusions from numerous observations:—1. A certain degree of heat is necessary to the voluntary phosphorescence of these animals.—2. Their phosphorescence is ex-

cited by a degree of heat superior to the first, and is irrecoverably destroyed by a higher temperature.—3. All bodies capable of coagulating albumen, take away from phosphorising matter its power of phosphorescence.—4. The phosphorescence cannot take place but in a gas which contains oxygen.—5. It is excited by the galvanic pile, but no effect is produced upon it by electricity.—6. The phosphorescent matter is composed principally of albumen.

ACOUSTICS.

5. *Velocity of Sound.*—M. Richard Van Rees, in an inaugural dissertation on Sound, has shewn theoretically, that the velocity of sound in common air is 341.54 metres in a second. In obtaining this result, he adopts the theory of Laplace, and founds his calculations on the data given by MM. Delaroche and Berard on specific heat. The experiments on the velocity of sound, made at Dusseldorf by M. Benzenberg, give for the velocity of sound 333.7 metres, about 2½ feet more than the velocity obtained from the experiments made at Paris.

6. *Propagation of Sound in Elastic Fluids.*—M. Van Rees, in the last chapter of the same work, has given the results of his experiments on the propagation of sound on elastic fluids, made with great care, and under the auspices of MM. Frameyer and Moll. The following are some of the results:

	Velocity 10° of Centig. therm.
Hydrogen,	1233.3 Metres.
Ammonia,	432
Vapour of water, temp. 54° cent.	422.6
Carbonic oxide,	341.1
Azote,	339.0
Carburetted hydrogen,	377.4
Oxygen,	317.7
Deutoxide of azote,	317.4
Sulphuretted hydrogen,	305.7
Hydrochloric acid,	298.8
Carbonic acid,	270.7
Protoxide of azote,	270.6
Vapour of alcohol,	262.7
Sulphurous acid,	229.2

A fuller account of these experiments will be found in the *Journal de Physique*, Jan. 1821, tom. xcii. p. 42.

ELECTRICITY.

7. *Singular Electrical Phenomena observed in Switzerland.*—On the 3d of May 1821, and when M. Allamand *jun.* was walking from Fleurier to Moutiers, in the canton of Neuchatel, he was overtaken by a storm of thunder and lightning. Having closed his umbrella, lest its metallic point should attract the lightning, he perceived a band of light along the rim of his hat. Upon passing his hand over the luminous train, it became still more luminous, and the whole interior of his hand shone like a polished metal when it reflects a bright light. Finding that there was no danger in making this experiment, he repeated it 15 or 20 times. This light was not attended with any crackling noise or electrical smell; it lasted only for a short time, and always resembled a brilliant varnish applied to the surface of his hand.

M. Allamand afterwards perceived another but less lively light upon the polished surface of the cross of his umbrella. Upon moving the slide over the luminous part, it became more brilliant, and in case of any accident he threw it from him. M. Allamand now tried to restore the luminous appearance to the rim of his hat, by rubbing it with the slieve of his coat, but he could not succeed, which he attributed to the tall poplars which grew on the side of the road having attracted the electricity from the atmosphere. When he recovered his umbrella, he saw luminous points at the extremities of the whalebone radii, which are terminated with a piece of metal. See the *Bibliotheque Universelle*, Juin 1821, vol. xvii. p. 154.

ELECTRO-MAGNETISM.

8. *Experiments of M. Yelin on Electro-Magnetism.*—M. Le Chevalier Yelin, a learned Bavarian, discovered some time ago, that needles of steel become magnetic when placed in a glass tube surrounded with a metallic spiral, and when electrical sparks or the charge of a Leyden battery were transmitted along the spiral. When the spiral was turned from left to right, and the sparks taken from the positive conductor, the end of the needle which points to it becomes a south pole, and the other the north pole, and *vice versa.*

If a third of the needle, reckoning from its middle, is surrounded in a spiral manner, with waxed taffetas, then the poles appear at the points where the spiral begins and ends. If, instead of a spiral wire, a rod of metal is extended along the glass tube, the steel needle placed within becomes feebly magnetic after several strong electrical discharges.

The poles of a magnetic needle were entirely reversed by several electrical discharges along the spiral.

9. *Experiments of M. Bockman on the intensity of Magnetism produced by Electricity.*—Dr Bockman of Carlsruhe has obtained the following curious results respecting the production of magnetism by electricity:

(1.) Electrical shocks from a plate machine 26 inches in diameter, gave to a steel rod a repulsive force upon the magnetic needle of 7°.

(2.) The following repulsions were obtained by the charge of a Leyden phial of 3.7 square inches of interior coating:

No. of discharges.	Repulsion on the N. pole of the Needle.	Repulsion on the S. pole of the Needle.
1	9°	12°
2	15	16
6	18	18
24	21	21.5
36	20.5	21.5

With a Leyden phial of 48 square inches of interior coating, the effects were:

1	17°.5	19°
2	22.5	24
6	27	29
14	27	30
24	27	30

With a Leyden phial of 300 square inches:

2	21°.5	23°
4	29	33
6	29	34
18	29	34

With a battery of *five* jars, with about 300 square inches each:

1	25°.5	26°.5
2	29	30
3	30.5	32
4	31.5	32
5	34.5	35
6	34	36
7	35	36.5

Dr Bockman next tried if the diameter of the steel needles had any effect on the result; and having used three of 1, 2, and 3 lines in diameter, he found that the larger ones received the magnetism more strongly than the smaller ones. The *maxima* of saturation took place between the 12th and 18th discharge.

The greatest effect which Dr Bockman obtained was repulsive of 52°.5 on the north pole, and 46°.5 on the south pole.

In determining the effect of the number of spires he obtained the following results.

No. of Spires.	Three Discharges.		Nine Discharges.		Fifteen Discharges.	
	N.	S.	N.	S.	N.	S.
1	No effect was observed.					
2	A slight trace of magnetism observed.					
4	9°	10°	13°	14°	13°.5	15°.0
8	13	14	17	17	17	18.0
16	16	17	20	21	21.5	22
32	18	19	22	23	23	22.5
64	19	20	22	23	24	24
128	24	26	28	28	28.5	28.5
174	23	25	27.5	27.5	27.5	27.5

When a spiral of 58 turns had half of the spires turned to the right, and the other half to the left, the two extremities of the steel needle placed in the tube became north poles, and the two south poles appeared in the middle of the needle. The repulsion of the north poles was 19° and 17°.5.

Tubes of glass were thus arranged, in several ways, with spirals. The steel needles were always rendered magnetic, and converted into several loadstones. A steel needle was placed in a tube of glass, and this within another tube of white iron, an inch in diameter, and this last in a second tube of glass, surrounded with a spiral-wire. After the first electrical discharge, the tube of white iron also became magnetic, the north pole shewing a repulsive force of 21°. The south pole lost its magnetism rapidly, and some minutes after the tube became indifferent. This experiment was often repeated; and, in every case, the steel needle in the interior remained indifferent; but, *when a tube of lead* was substituted in place of the white iron, it became magnetic, with a repulsive force of 14° and 16°.

A needle of nickel placed in a tube surrounded with a spiral, did not become magnetic after several strong electrical discharges.

Dr Bockman now tried spirals of a large diameter. In the middle of a spiral 34 inches in diameter, was placed a tube of glass, with a steel needle, and the following were the results with a jar of 300 square inches.

	Repulsion North Pole.	Repulsion South Pole.
1	10°	13°.5
2	14	16.5
3	14	17
4	15	18
5	16	20.5
6	16	19

In these experiments, Dr Bockman found that *needles of steel placed without the spiral, and near it, became more or less magnetic*, by the effect of electrical discharges; but that they had their poles opposite to those placed within the spiral.

With a spiral 84 inches in diameter, the effect on the needles was just perceptible.

Another spiral between 34 and 84 inches was tried; but its effect was not much greater than that produced by a spiral of 84 inches.—See the *Bibliotheque Universelle*, Juin 1821, vol. xvii. p. 125.–133.

METEOROLOGY.

10. *Mean Temperature at Carbeth for the Years* 1817, 1818, 1819, 1820.—The observations were made at 10 o'clock A. M. Lat. 55° 59′ 50″; Long. 4° 21′ 52″ W. Height above the level of the sea 480 feet. The thermometer was made by Crichton.

Month.	1817.	1818.	1819.	1820.	Mean.
January,	37°.4	37°.1	37°.5	30.5	35°.6
February,	39.9	35.7	36.9	39.8	38.1
March,	37.7	37.7	43	41.8	40
April, -	40.1	41.2	45.9	49.5	44.2
May, -	44.8	50.7	52	53.1	50.1
June, -	59.5	59.6	55.7	58.2	58
July, -	60.2	63	62.6	61.8	61.9
August,	56.9	60.3	66.5	57.4	60.3
September,	56.5	55.3	55.5	55.3	55,6
October,	43.5	52	47.4	46.9	47.4
November,	44.5	46.4	37.5	42.5	42.7
December,	34.6	38.3	32.5	32.9	36.2
Mean,	46°.3	48°.1	47°.6	48°	47°.5

It appears from the Rev. Mr Gordon's Observations made at Kinfauns, (see this *Journal*, vol. ii. p. 371.) that the mean temperature of the year, as taken at 10^h A. M. is 1°.8 greater than the mean temperature taken at 10^h A. M. and 10^h P. M. Hence we have for the mean temperature of Carbeth,

	47°.5
	1.8
rature of Carbeth, . . .	45.7
Add for 480 feet of Elevation, . .	1.4
Mean Temperature at the level of the sea, . .	47.1
Mean Temperature of Carbeth, according to Dr Brewster's formula, (Lat. 55° 59′ 50″), . .	45.6
Difference,	1.5

11. *Quantity of Rain that fell at Carbeth in the years* 1815 *to* 1820.—The rain-guage was fixed on the top of the house.

Month.	1815.	1816.	1817.	1818.	1819.	1820.	Mean.
January,	0.750	3.869	4.696	6.854	4.722	3.970	4.143
February,	4.855	3.259	4.562	5.025	4.195	1.696	3.932
March,	5.563	2.807	4.610	2.923	2.841	2.625	3.561
April, -	1.430	1.673	.322	.680	3.665	2.093	1.644
May, -	3.684	3.442	3.371	1.390	3.450	6.435	3.629
June, -	1.831	2.750	4.405	3.364	3.666	1.885	2.950
July, -	1.711	4.623	3.246	4.802	3.025	2.310	3.286
August, -	3.638	1.609	6.185	1.266	2.405	6.173	3.546
September,	5.552	6.095	2.163	2.914	3.510	4.212	4.074
October,	5.308	2.672	1.350	4.375	4.074	2.630	3.401
November,	3.869	2.850	4.470	5.034	3.412	2.966	3.768
December,	3.202	3.940	5.585	2.760	3.880	3.626	3.832
Fallen in each Year,	41.393	38.589	44.965	41.387	42.845	40.621	41.766

12. *Gelatinous Meteor at Amherst in Massachussets.*—On the 13th August 1819, between eight and nine o'clock in the evening, a fire-ball, of the size of a large blown bladder, and of a brilliant white light, was seen in the atmosphere. It fell near a house, and was examined by Rufus Graves, Esq. formerly Lecturer in Chemistry at Dartmouth College. It was of a circular form, resembling a solid dish, bottom upwards, about 8 inches in diameter, and about 1 in thickness, of a bright buff colour, with a fine nap upon it, similar to that in milled cloth. On removing this nap, a buff-coloured pulpy substance, of the consistence of soft soap, appeared, having an offensive suffocating smell, producing nausea and giddiness. After a few minutes exposure to the air, the buff colour was changed into a livid colour, resembling venous blood. It attracted moisture readily from the air. A quantity of it in a tumbler soon liquified, and

formed a mucilaginous substance, of the consistence, colour, and feeling of starch, when prepared for domestic use. The tumbler was then set in a safe place, where it remained undisturbed for two or three days, and it was found to have all evaporated, except a small dark-coloured residuum adhering to the bottom and sides of the glass, which, when rubbed between the fingers, produced about a thimbleful of a fine ash-coloured powder, without taste or smell. With concentrated and diluted muriatic and nitric acids, no chemical action was observed, and the matter remained unchanged. With the concentrated sulphuric acid, a violent effervescence ensued, a gas was evolved, and the whole substance nearly dissolved.—*American Journal of Science*, vol. ii. p. 335.

13. *Singular Appearance of Snow and Hail.*—In January 1809, the Rev. D. A. Clark observed, in Morris County, New Jersey, a regular formation of cylinders of snow. When a deep snow was upon the ground, a shower of rain fell, and, in consequence of a sudden cold, the rain was congealed on the surface of the snow, and formed upon it a cake of ice. Another shower of snow fell to the depth of three-fourths of an inch, and the sky having suddenly cleared, the cold became very intense, and the wind blew a gale. "Nature," says Mr Clark, "now began her sport. Particles of the snow would move upon the icy crust from 12 to 20 inches, and would then begin to roll, making a track upon the ice shaped like an isosceles triangle. The balls enlarged according to circumstances, and, aided by the declivity of the ground, the rolls were of the size of a barrel, and some even larger. Thus the whole creation, as far as the eye could see, was covered with snow-balls, differing in size from that of a lady's muff to the diameter of $2\frac{1}{2}$ or 3 feet, hollow at each end to almost the very centre, and all as true as so many logs of wood shaped in a lathe."

About two years before, Mr Clark observed in the heat of summer hailstones about one-fourth or three-eighths of an inch thick, and of sufficient size to hide a shilling. Almost every one of them was perforated in the middle, as if they had been held between the fingers, till the fingers by their warmth had melted away the middle, and had met. When the perforation was not complete, there was in every case an inclination to perforation.

Mr E. Hitchcock observed, at Deerfield, in Massachussets, in 1812 or 1813, cylinders of snow similar to those above described by Mr Clark, and formed under similar circumstances. None of the cylinders, however, were more than six or eight inches in diameter.—*American Journal of Science*, vol. ii. No. 1. p. 132. and vol. ii. No. 2. p. 375.

II. CHEMISTRY.

14. *Daniell's New Platinum Pyrometer for High Temperatures.*—The only pyrometer for high temperatures which has hitherto been used, is that of our late eminent countryman Mr Wedgewood, which was founded on the principle, that clay contracts in bulk, in proportion to the intensity of the heat which is applied to it. The difficulty, however, of obtaining clay pieces of uniform composition, and the discovery that the same degree of contraction may be obtained by the long continuance of a low temperature, and the short continuance of a high one, have prevented this instrument from coming into general use, and have thrown an uncertainty over the results given by Mr Wedgewood.

The new pyrometer invented by Mr Daniell is very simple in its construction, is easily repaired when injured, and will extend the scale of the thermometer at least to the fusing point of cast iron. It distinctly indicates a change of about *seven degrees* of Fahrenheit's scale.

The instrument consists of a bar of platinum $10\frac{1}{3}$ inches long, and 0.14 of an inch in diameter. It is placed in a tube of black lead earthen ware, and the difference between the expansion of the platinum bar, and the earthen-ware tube, is indicated upon a circular scale, in consequence of a fine platinum wire $\frac{1}{100}$th of an inch in diameter, which is fixed to the end of the platinum bar, and is coiled three or four times round the axis of a small wheel, which we shall call A, fixed at the back of the circular scale. The other end of the small platinum wire is bent back, and attached to the extremity of a slight spring which keeps the wire in a state of extension. The axis of the wheel A is 0.062 of an inch in diameter, and the wheel itself is toothed, and plays in the teeth of another smaller wheel *a*, whose diameter is

one-third of A, and which has one-third of the number of teeth. An index fastened to the axis of the small wheel *a*, indicates the temperature of a circular scale, which is divided into 360°. Instead of passing the platinum-wire round the axle of the wheel A, it has been found better in practice, to attach a short silken thread to its extremity, and pass that round, and fix it to the spring.—See *Journal of Science*, &c. vol. xi. p. 309.

15. *Results obtained by Mr Daniell's New Pyrometer.*—The experiments by which the following results were obtained, were repeated more than once, with a very close agreement of results. The fusing point of silver is most to be relied upon, as Mr Daniell obtained it by three different trials, all within a degree of one another.

	Daniell's Scale.	Fahr. Thermometer.	Wedgewood's results.
Boiling point of Mercury,	92°	644°	600°
Fusing point of Tin, - -	63	441	
———— Bismuth, -	66	462	
———— Lead, - -	87	609	
———— Zinc, - -	94	648	
———— Brass, - -	267	1869	3807
———— Pure Silver, -	319	2233	4717
———— Copper, - -	364	2548	4587
———— Gold, - -	370	2590	5237
———— Cast Iron, -	497	3479	17977
Red heat, just visible in day-light,	140	980	1077
Heat of a common parlour-fire,	163	1141	

The difference between these results and those obtained by Mr Wedgewood, appears from the last column of the preceding table. Mr Daniell terminates his paper with the two following facts: 1*st*, That mercury amalgamates readily with platinum at about its boiling temperature. When the mercury is volatilised by a strong red heat, the platinum is left in a honeycomb or dissected state. 2*d*, A piece of cast iron, strongly heated, and then cooled slowly in a muffle, becomes covered with small, but very distinct, octohedral and tetrahedral crystals, and black oxide of iron. The facets of the crystals were very perfect and brilliant.—*Journal of Science*, vol. xi. p. 317.

III. NATURAL HISTORY.

ZOOLOGY.

16. *Sword-fish cast ashore at Kirkbean.*—The present summer has been remarkable for the number of large and strange fishes which have been thrown upon our coasts, particularly those washed by the Irish Sea. Perhaps the most remarkable of these is a sword-fish, the *Xiphias gladius* of Linnæus, which was thrown on the coast of Kirkbean, a small maritime tract situated immediately behind that formidable barrier of shallows and sand-banks which protect the western alluvial border of the Solway Frith from the incursions of its ancient possessor, the ocean. This fish measured 10 feet in length, and 4½ feet round the thicker part of the body. The sword, or rostrum, which is the most interesting part of this singular animal, measures 3 feet 3 inches in length; and, different from those specimens commonly exhibited or described, resembles in a most remarkable manner the common diamond sword worn by the serjeants of infantry, only its proportions at the root are more uniform, the whole figure being that of a very acute isosceles triangle, whose vertical angle is 4° 42′;—for its greater section is nearly a rhomboid, whose respective sides are 17.5, 33: which last number is its transverse dimension or breadth at the same place in $\frac{1}{10}$ths of an inch. Its thickness there is 3.1 inches: its greatest breadth 3.3 inches; and it weighs 25 ounces, or 1 lb. 9 oz. avoirdupois.

The part where the rostrum has been attached to the frontal bone is somewhat softer than the rest, though approaching more nearly to the colour and surface of bone. Internally, however, the appearance is splintery, with parallel fibres, and colour much resembling hiccory. Towards the apex, it becomes more and more solid, and its edges are almost perfectly transparent, and might pass for a deposition of calcareous-spar. They are, indeed, easily scratched with a knife, and yield a white streak, but do not effervesce with acids. The point, which does not exceed $\frac{1}{20}$th of an inch in breadth, is likewise, though less perfectly, transparent. It is penetrated for at least 18 inches of its length by four canals. These are half an inch wide at their commencement, and gradually disappear in solid bone. Their use is probably to receive nerves for the purpose of sensation, as the whole mass

seems possessed of a strong vibratory power, and, when the nasal end of it is held close to the ear, the slightest touch on the other extremity is instantly perceived. The stethoscope of M. Lænnec rather diminishes than increases this interesting effect. Whoever considers the dimensions, and exquisite mechanical aptitude of this dreadful weapon, more especially when sped with the almost electrical velocity of a fish 10 feet long, and nearly (by computation) half a ton in weight, will have little difficulty in conceiving the effect described by Mr Scoresby in Vol. III. p. 411. of this Journal. The rostrum there described could only have been 28 inches in length, or almost one-half less than that we are now describing; yet the fish had driven it through the bow of a vessel, (the Kitty of Liverpool), where the thickness in timber and planks was 12 inches of sound oak, besides a sheath of copper. The violence of the shock, however, seems to have broken off the rostrum close to the os frontis. It is very thin there, not $\frac{1}{30}$th of an inch; and though Galileo has shewn that matter disposed as here in a hollow cylindrical form is stronger than when solid, this only obtains in the case of pressure exerted at a distance from the point of resistance; for it must be proportionally weaker, in the event of a shock or oscillation, which, in the instance supposed, would undoubtedly be tremendous. However, the rostrum described by Mr Scoresby was cylindrical; that above described is flat, but sloping from a regular angle (of 141°) in its middle to a moderately blunt edge on either side. This bevelment is most remarkable on the upper surface, while the lower is marked by *two* corresponding lines, not sharp but rounded. A small suture may be observed on both surfaces, continued from the frontal bone to within six inches of the point, and dividing the rostrum into two equal parts. It seems difficult to conjecture what cause can have seduced this animal so far from the seas which he usually inhabits, and to a coast where few varieties are to be met with, beyond the native tenants of the rivers and banks of Solway. The oldest inhabitants of the adjoining district do not recollect another instance; and if we connect this with the numerous accounts of large fishes lately thrown ashore on the neighbouring coasts, and the almost unprecedented dry season which has just been terminated, it will appear not improbable that these

events have a natural dependence on each other. The fishermen of that quarter know how to appreciate the effects of shorter seasons of drought on the fish proper to the coast; and when the term has been prolonged to nearly five times its average duration, it seems rational to infer, that its effects have likewise been carried to a proportionally greater distance among the inhabitants of the deep, and brought the stately stranger we have been considering into shallows, from which all his strength and activity were unable to relieve him.—*Mr Edward Milligan.*

IV. GENERAL SCIENCE.

17. *Account of the Rattlesnake.*—Mr James Pierce, in his Account of the Geology, Scenery, &c. of the counties of Newhaven and Litchfield, has given the following interesting account of the rattlesnake. A young man having met with a large and vigorous rattlesnake, instead of killing it with his long cart-whip, as he could easily have done, amused himself by provoking it, and gently playing his whip around its body. The irritated reptile made repeated and vigorous leaps towards the young man, coming nearer to him at every effort; and, being teazed more and more with the whip, at last threw himself into the air, with such energy, that when he descended, he seemed scarcely to touch the ground; but instantly rebounding, executed a succession of leaps, so rapid and so great, that there was not the slightest intermission, and he appeared to fly. The young man betook himself to a rapid flight; but his dreadful pursuer gained rapidly upon him, till approaching a fence, he perceived that he could not pass it before the fangs of the snake would be hooked in his flesh. As his only resource, he turned, and by a fortunate throw of his lash, by which he wound it completely round the serpent's body, he arrested his progress, and killed him.—Mr Pierce had a living rattlesnake two months in his possession, and every day watched his manners. He immediately killed birds and most small animals, when put into his cage, but did not eat them. He permitted a toad, however, to remain weeks with him unmolested, and allowed it to leap upon his body, and sit upon his head. When he opened his mouth, his fangs were not visible unless he was provoked; at other

times they were covered with a membrane like a scabbard, only they were drawn back, so that the sheathing membrane formed only a slight protuberance on each side of the upper jaw. If irritated, he flattened his head, threw it back, opened his mouth wide, and instantly the fatal fangs were shot out of their sheaths, like a spring-dagger, and he darted upon his object.—"After his death," says Mr Pierce, "I examined the fangs: they are shaped like a sickle; a duct led from the reservoir of poison at the bottom of the tooth, quite through its whole length, and terminated just by the point, which was exceedingly sharp. Thus the fang is darted out at the will of the animal; it makes the puncture at the instant, and simultaneously the poison flows through the duct, and is deposited in the very bottom of the wound. As this rarely fails to touch a bloodvessel, the venom is thus instantly issued into the system, and without delay commences the march of death through every vein and artery."—*American Journal of Science*, vol. ii. p. 229.

18. *Drift-Wood accumulated in the Achafalaya.*—The quantity of wood drifted into the River Achafalaya is so enormous, that several hundred miles are converted into solid rafts of wood, which, in the course of every two or three years disappear under the sand and leaves. By this operation, the bed of the Achafalaya is alternately removed four or five miles to the east, or two or three to the west, but more commonly to the east. On that side, it has already gained more than ten miles since it has become an outlet of that river. When Mr Bringier landed at the mouth of this river in 1812, when it was at the fullest, he was surprised at the quantity of wood leaping perpetually into the shoot. He then counted the large trees entering the river in a given time, and found that more than 8000 cubic feet passed in a minute, besides leaves, bark, reeds, &c. whose united quantity is probably equal to that of the wood. The rafts on the Red River are equally remarkable. This river is about sixty miles in length, and in many places fifteen miles in breadth. In some parts of this river, cedar trees are heaped up by themselves, and in other places pines. At the foot of a hill where nothing else grows, the flood sweeps them into a pile, where they are matted together with their leaves, and with the pods

or capsules of their seeds, forming the most compact kind of rafts. Under this raft of the Red River, various small streams disappear, and shew themselves again after having passed several miles under the surface, and under sand banks, which are probably part of the raft buried under the sand.—The rafts on the Achafalaya have been more recently examined by Mr Darby, who has given an account of them in his *Emigrant's Guide.* He remarks, that men may pass the river in many places upon the wood. The timber, he says, rises and falls with the water, —is continually shifting,—lies in all directions, having large interstices open,—and frequently moves in a body from the weight of the incumbent mass. The raft is described by Mr Darby as only twenty miles long from its upper to its lower extremity, ten miles of which is completely closed with timber.—*American Journal of Science*, Vol. iii. No. 1. p. 17.—21.

19. *Rewards for Discoveries in the Arctic Regions.*—In the New Longitude Act, which is the 58th of Geo. III. amended, it is assumed, that no ship has gone beyond 81° of North Lat. and 113° of West Long. within the Arctic circle. The rewards which it proposes are:

- L. 5000 to any subject of Great Britain who shall reach the Longitude of 130° from Greenwich, within the Arctic Circle;
- L. 10,000, besides the above, for the North-West Passage into the Pacific;
- L. 1000 for reaching 83° of North Lat., and a similar sum for 85°, 87°, and 89°, respectively.

20. *Mr Campbell's second Journey in Africa.*—"As to the nations beyond Lattakoo which I visited," says Mr Campbell, "the first was the Tammaha nation, the chief town of which was Meribowhey, which lies near 200 miles to the NE. of New Lattakoo. They abound in cattle, and cultivate, to a considerable extent around their town, a species of millet, called Kaffer Corn.—The next country beyond the Tammaha is the Mashow country, the chief town of which is Mashow, not a day's journey beyond Meribowhey, containing about 12,000 inhabitants, who are much in the same state as at Lattakoo, and speak the same language.—About 100 miles beyond Mashow is Kurree-

chane, the chief town in the Marootzee country, containing about 16,000 inhabitants, with several large towns in the vicinity. These are much more civilised than any of the nations nearer the colony of the Cape. They smelt and work in iron and copper; paint the walls of their houses in the inside; work very well in pottery; have a regular government, which is monarchical; and speak the same language as at Lattakoo, as do many nations beyond them to the north: They abound in cattle, and have an extensive cultivation. I think Kurreechane lies in the 24th degree of South Lat. New Lattakoo lies near the source of the Krooman River. On my return from Kurreechane, I went down the Krooman, which runs to the westward, and found several towns on its banks. Though a considerable stream, I found it lost itself at the side of the Great Southern Zahara Desert. I travelled two days' journey into that desert, to a group of hills in which is the town of Tureehey, where the King of the Matslaroo nation resides. The houses resembled those of Lattakoo: they live by cattle and cultivating the ground. I found in the desert two or three small kraals or towns of the Cavanna nation. I think Kurreechane was about 300 miles to the NE. of New Lattakoo, and Tureehey about 100 miles to the west. These appear trifling distances to mail-coach travellers, in countries where there are both roads and bridges, but in countries where there are neither, it requires much time and exertion. At Botany Bay, or Port Jackson, for the first thirty years, they only penetrated seventy miles into the interior to the Blue Mountains; and even yet, they have not got much above a hundred, which proves the difficulty. After we have a mission established at Kurreechane, much of the *terra incognita* beyond will soon be made known to Europeans; and I believe, with some wise men, that only in that way will the interior of Africa be made known to Europeans: the hazard is very great in going far beyond where reports of white men have reached, for every thing you have is desired by the savages, and there is no law to protect you."

21. *Eruption of Carbonised Wood at New Madrid.*—During the earthquake which destroyed New Madrid on the 6th of January 1812, and which was felt two hundred miles around, Mr Bringier happened to be passing in its neighbourhood,

when the principal shock took place. The violence of the earthquake having disturbed the earthy strata impending over the subterraneous cavities existing probably in an extensive bed of wood, highly carbonised, occasioned the whole superior mass to settle. This mass pressing upon the water which had filled the lower cavities, forced it out, and blew up the earth with loud explosions. It rushed out in all directions, bringing with it an *enormous quantity of carbonised wood, reduced mostly into dust, which was ejected to the height of from* 10 *to* 15 *feet*, and fell in a black shower, mixed with the sand which its rapid motion had forced along: at the same time, the roaring and whistling, produced by the impetuosity of the air escaping from its confinement, seemed to increase the horrible disorder of the trees, which every where encumbered each other, being blown up, cracking and splitting, and falling by thousands at a time. In the mean time, the surface was sinking, and a black liquid was rising up to the belly of Mr Bringier's horse, which stood motionless, struck with panic and terror. These occurrences occupied nearly two minutes. The trees kept falling here and there, and the whole surface of the country remained covered with holes, which, to compare small things with great, resembled so many craters of volcanoes, surrounded with a ring of carbonised wood and sand, which rose to the height of about seven feet. The depth of several of these holes, when measured some time after, did not exceed twenty feet, but the quicksand had washed into them. Mr Bringier noticed a tendency to carbonisation in all the vegetable substances that had been soaking in the ponds, produced by these eruptions.—*American Journal of Science*, vol. iii. No. 1. p. 20.

22. *Effects of Cold upon Ice.*—On Lake Champlain, and other American lakes, and even on narrow rivers, fissures and rents of enormous magnitude are often made in the ice, and are always accompanied with loud reports, like those of cannon. The unwary traveller, who, with his sleighs and horses, adventures by night, and sometimes even by day, across the great northern lakes, is frequently swallowed up in the openings, which are thus unexpectedly made in the ice. When the weather grows warm again, before the ice melts, the fissures close, and sometimes the edges of them even overlap. At Plattsburg, in the

winter of 1819-20, when the thermometer during night was from 15° to 17° below 0° of Fahr., and during the day, from 10° to 12° below it. The reports of the rending ice were like that of a six-pounder, and the openings were from 10 to 15 feet wide.—See *American Journal of Science*, vol. ii. No. 1. p. 177.

23. *New Volcano near Leiria, in Portugal.*—It is stated in the Gentleman's Magazine for April, that a volcano has burst out on the highest summit of a ridge of mountains, near Leiria, in Portugal. It occurred at the period of the high rise of the Douro, and was in full eruption when the latest accounts were dispatched.

24. *Eruption of a Spring near Ripon.*—On the 18th of April 1821, a portion of the avenue of Mr Charnock, at Bishop Moncktown, near Ripon, was seen in a considerable state of agitation for some minutes. An opening, of about a foot square, then appeared, and from this there issued a body of water, which ebbed and flowed during the day. The cavity was gradually enlarged, by the successive eruptions of the spring, and, when plumbed in the evening, was found to be 58 feet deep.—*Gentleman's Magazine*, May 1821, p. 461.

25. *Tree which produces the Caoutchouc, or Elastic Gum.*—In the region of the Missisippi, on the Arkansas and Red River, grows the tree which yields the vegetable caoutchouc. It has a tolerably smooth back; and when incisions are made in it, a milky fluid exudes, which coagulates, and forms elastic gum. Some trees yield from 150 to 200 pounds of caoutchouc. Mr Bringier observed, that the wood of it was very elastic, when dry. If rubbed on a body which is electric, particularly in a cold day, the body rubbed will adhere to the wall. A quill, for example, will be attracted six inches from the wall, and stick fast to it, till all the electricity is dissipated.

26. *Account of the Leech of Ceylon.*—This animal is seldom more than half an inch long, and is nearly semitransparent. It is very active, and is said occasionally to spring. Its powers of contraction and extension are very great. It is like a fine cord when fully extended, and its point is so sharp that it easily makes its way through very small openings. It is sup-

posed to have an acute sense of smell, for no sooner does a person stop where leeches abound, than they appear to crowd eagerly to the spot from all quarters. "Those who have had no experience of these animals," says Dr Davy, "of their immense numbers in their favourite haunts,—of their activity, keen appetite, and love of blood, can have no idea of the kind and extent of annoyance they are to travellers in the interior, of which they may be truly said to be the plague. In rainy weather, it is almost shocking to see the legs of men on a long march, thickly beset with them, gorged with blood, and the blood trickling down in streams. In attempting to keep them off, they crowd to the attack, and fasten on quicker than they can be removed. I do not exaggerate, when I say that I have occasionally seen at least fifty on a person at a time. Their bites are apt to fester, and become sores, and frequently degenerate into extensive ulcers, which, in too many instances, have occasioned the loss of limb, and even of life."—Dr Davy's *Account of the interior of Ceylon.*

27. *Removal of a Paralytic Affection by Lightning.*—Mr Olmsted, Professor of Chemistry in the College of North Carolina, has published, in the American Journal of Science, vol. iii. No. 1. p. 100. an account of the removal of a paralytic affection by a stroke of lightning. Mr Samuel Leffers of Carteret County, North Carolina, had been affected with a paralytic affection in his face, which had settled chiefly in the eye. When he was walking in his house during a thunder storm, he was struck down by lightning. After lying senseless fifteen or twenty minutes, he recovered so far as to be sensible of his situation. He recovered the use of his senses and of his limbs by degrees, during the remainder of the day and night, and he felt so well the next day, that he was inclined to give to a distant friend an account of what had happened. He was able to write a long letter, without the use of glasses. Since that time he never felt a symptom of the paralytic disorder; and he concluded, that it had been effectually cured by the shock. He thought, however, that the same cause which restored his sight impaired his hearing.

28. *Altitude of Dhwalagiri and other Mountains of the Himalaya.*—The superior altitude of the Himalaya range to the moun-

tains of the Andes has been established beyond a doubt, by the survey of Captain Blake. The following are the altitudes deduced from his observations, by Mr Colebrooke:

	Altitude in Feet above the Sea.
Peak without name, - - - -	21,935
Chandragiri, or Mountain of the Moon, -	23,007
Peak without a name, - - - -	24,108
Swelagar or Nepal, - - - -	25,261
Dhwalagiri, or Ghasu Coti, or the White Mountain,	28,015

See the *Journal of Science, Literature, &c.* vol. xi. p. 240.

29. *Third Report of the Commissioners of Weights and Measures.*—The following is the substance of the final report of the Commissioners of Weights and Measures, viz. Sir George Clerk, Bart., Davis Gilbert, Esq. Dr Wollaston, Dr Young and Captain Kater:

"1. That the Parliamentary standard-yard made by Bird in 1760, be henceforward considered as the authentic legal standard of the British Empire; and that it be identified, by declaring, that 39.1393 inches of this standard, at the temperature of 62° of Fahrenheit, have been found equal to the length of a pendulum, supposed to vibrate seconds in London on the level of the sea, and in a vacuum.

"2. That the Parliamentary standard Troy pound, according to the two pound weight made in 1758, remains unaltered; and that 7000 Troy grains be declared to constitute an Avoirdupois pound; the cubic inch of distilled water being found to weigh at 62°, in a vacuum, 252.72 Parliamentary grains.

"3. That the ale and corn gallon be restored to their original equality, by taking for the statutable common gallon of the British Empire, a mean value, such that a gallon of common water may weigh 10 pounds Avoirdupois in ordinary circumstances, its content being nearly 277.3 cubic inches; and that correct standards of this imperial gallon, and of the bushel, peck, quart and pint derived from it, and of their parts, be procured without delay, for the Exchequer."

30. *Plant which Dissolves in Water.*—The plant called *Nostoch communis,* which is found in the south of France, in the form of a green and membranaceous envelope, filled with a species

of jelly, containing a number of elongated filaments, has the remarkable property of dissolving in water. It always disappears when the rain has ceased, leaving only a small dry membrane, apparently inorganised, which resumes its original form, by being wetted. A curious paper on this plant, and on the different names it has received, is published by M. Vallot, in the *Journal de Physique*, Mars 1821, tom. 93. p. 216,—227.

31. *Impediments of Speech.*—All *impediments of speech* may be divided into two kinds, *natural* and *artificial*. *Natural* impediments arise from a diseased or misconstructed state of the organ of speech. *Artificial* impediments are certain acquired habits, occasioned by a false application of the organs, and other causes. *Natural* impediments are so very rare, that not *one* case in *five hundred* of those affected with impediments of speech, can be traced to physical causes. But there are *other* causes that operate most powerfully in preventing those afflicted with impediments, from submitting to a proper course of tuition; and, finally, of having them completely removed.—Medical men too frequently assert, when any case of marked impediment of speech is submitted to their examination, that it arises from a deficiency, or malconformation of the organ of speech; and is therefore incurable. This is most distressing, because many of these very cases, however, have been found to be purely *artificial*, and under proper management, and a due course of tuition, the supposed *natural* impediments have been completely removed.—Another prevailing opinion, which has a powerful effect in preventing any attempt to remove impediments of speech, without any respect to the *origin* of the evil, is, that they are incurable, and of course, without farther investigation, it is taken for granted that all plans to effect a cure are nugatory and delusive. This opinion has, unfortunately, been too frequently confirmed by the misgiving of success with those, who, without hesitation, pretend to remove all impediments of speech, natural or artificial.—Parents and guardians ought to know, that impediments of speech are, in most cases, contagious, and are often attended with the most serious consequences, where there are younger branches in the family;—that many impediments, which, had they been taken in time, might

have been easily removed, increase by habit to such a degree, as to induce imbecility of intellect;—that they are the means of preventing the acquisition of the most important branches of education, and, of course, the improvement of the mind;—that they operate as a complete exclusion from those useful and eminent situations, offices and professions, for which the person afflicted with impediments of speech, is, in every other respect, peculiarly qualified;—that they exclude from society, or render silent when in it, those who might hold a conspicuous rank in the most learned and intellectual circles;—that their attempts at conversation, even on the most trivial subjects, and in the bosom of their own family, never fail to put their most intimate friends to the blush; and their violent contortions, and nervous affections, are painful in the extreme to themselves, and excessively disagreeable to all with whom they converse.—When such consequences follow the generality of artificial impediments of speech, is it not highly culpable for those parents and guardians, who are responsible for the education of the young people placed under their care, to neglect the most early and favourable means of having all impediments of speech and defects of utterance eradicated, before they grow into habits, which no scientific knowledge can overcome, and which baffle every attempt, even at any degree of amelioration? To develope organs of speech previously inactive, to give distinctness of articulation to unintelligible muttering, musical enunciation to minced and harsh sounds, to give speech to the mute, and fluency of utterance to the convulsive stammerer, are objects, we think, of no ordinary degree of importance.—The time necessary to accomplish these great ends, must depend on the knowledge of the professor of the art, and his mode of tuition; it must greatly depend on the extent of the perfection required by the pupil; the nature and degree of the impediment, or habit to be encountered; and the susceptibility, diligence, previous attainments, and dispositions of the pupil.—Edinburgh has been long in want of a professional gentleman, whose experience, education and success entitle him to public confidence; and we are fully aware, that many inquiries, by anxious and affectionate parents, are frequently made for a person who is qualified for the important task of removing impediments of speech. We are

happy in having it in our power to recommend the Reverend James Chapman, teacher of elocution here, as a gentleman well qualified for this arduous, but most important undertaking. No considerations of a private nature would have induced us to insert in this Journal any such recommendation; but having witnessed the remarkable success of Mr Chapman's methods, we feel that we are discharging a duty both to the public and to him, in making this statement; and we think that our metropolis will have made no ordinary acquisition, if it shall secure the permanent residence of such a well educated and accomplished teacher as Mr Chapman.

ART. XXV.—*List of Patents granted in Scotland from 1st June to 1st September* 1821.

17. TO JEAN FREDERIC, Marquis of Chabanes, of Russel Place, Fitzroy Square, county of Middlesex, for his "Invention" of a "New Method and Apparatus for attracting and catching of Fish." Sealed at Edinburgh the 24th August 1821.

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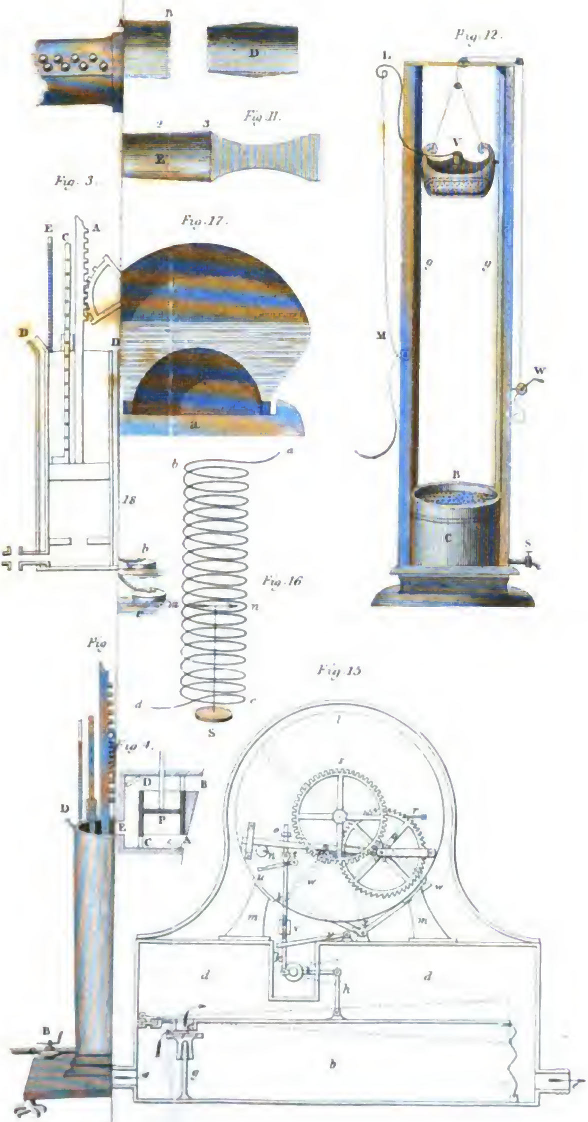

Lizars Sculpt.

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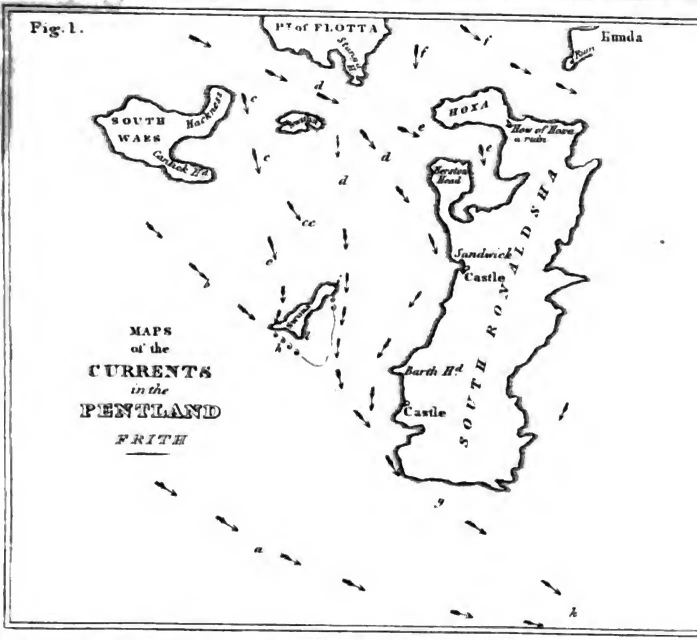

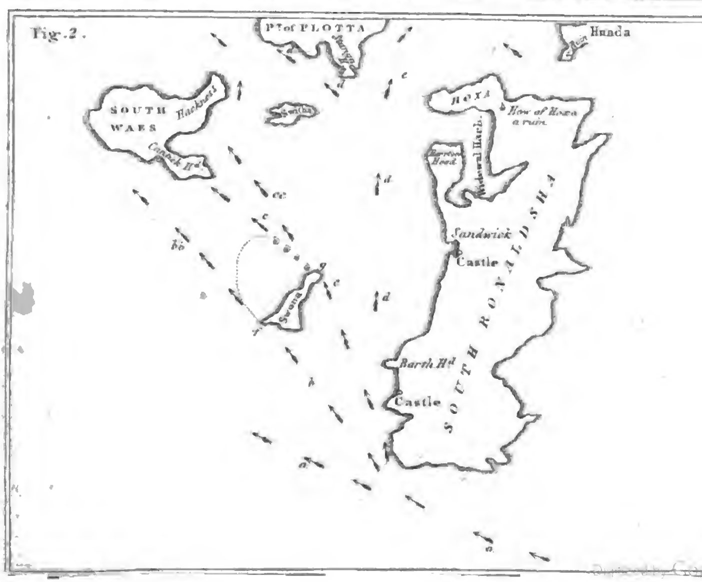

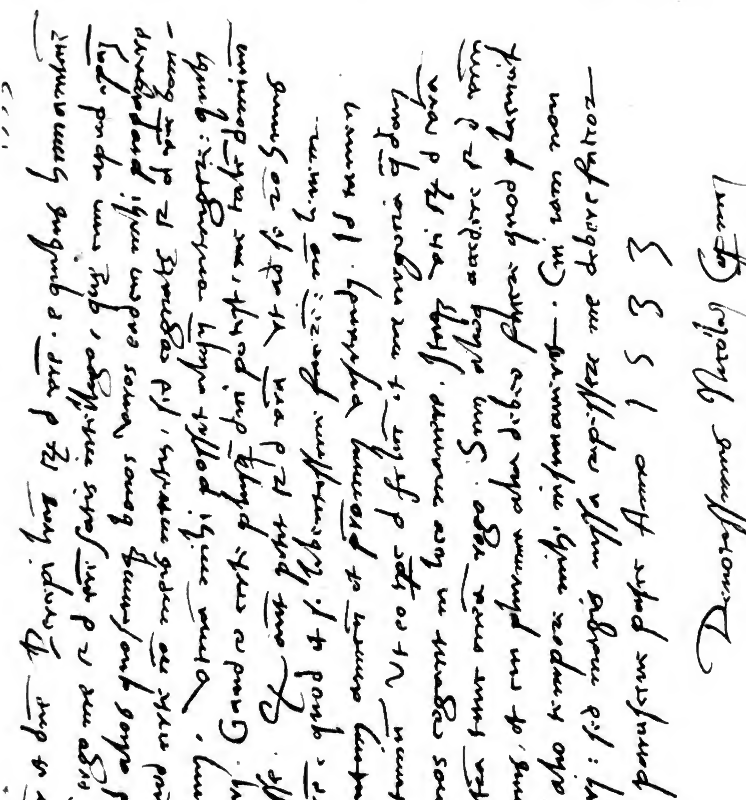

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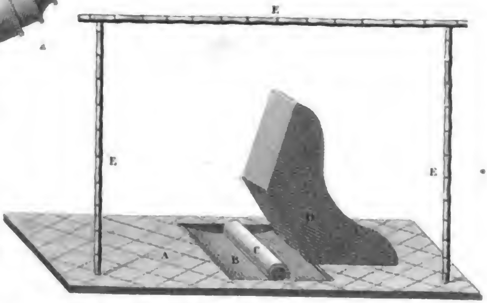
Fig. 2.

Fig. 1.



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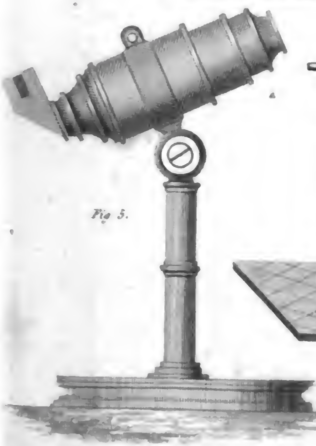
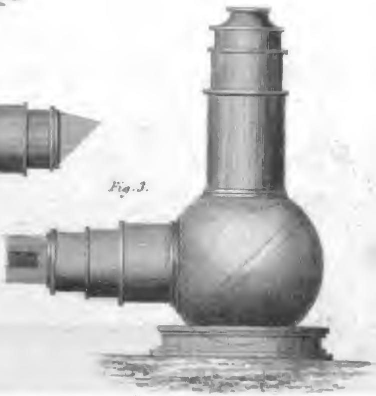


Fig. 4.

Fig. 3.



[illegible] Sculp^t

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…VE OF TAUNU . PLATE V. Edin.r Phil. Jour. Vol. VI.

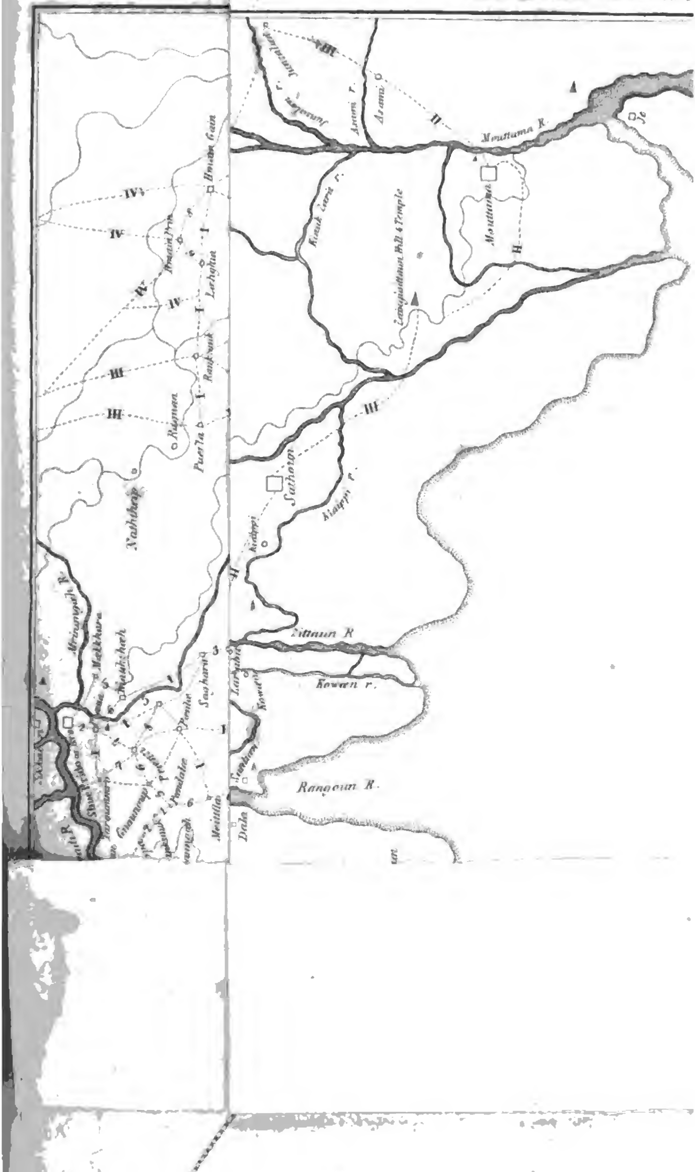

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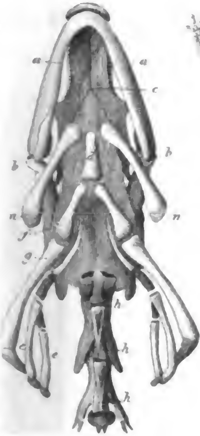
Fig. 1.



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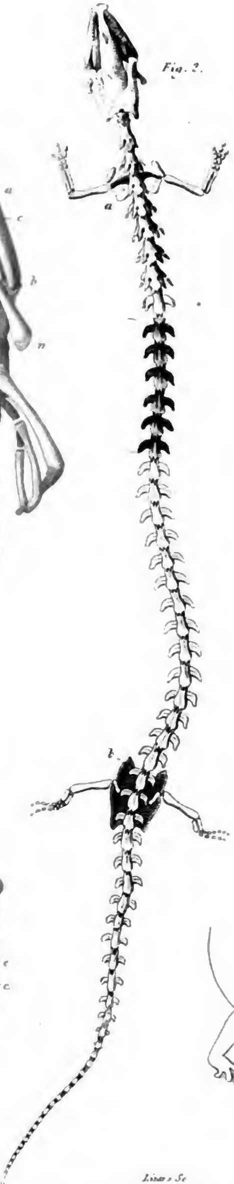

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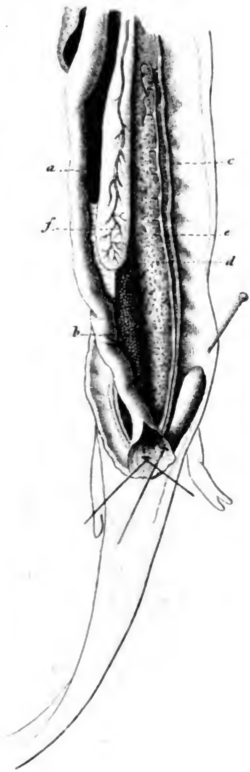

Fig. 4.

Fig. 5.

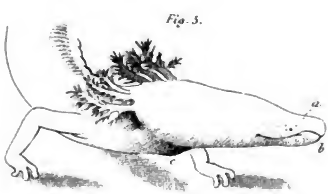

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PLATE VII.

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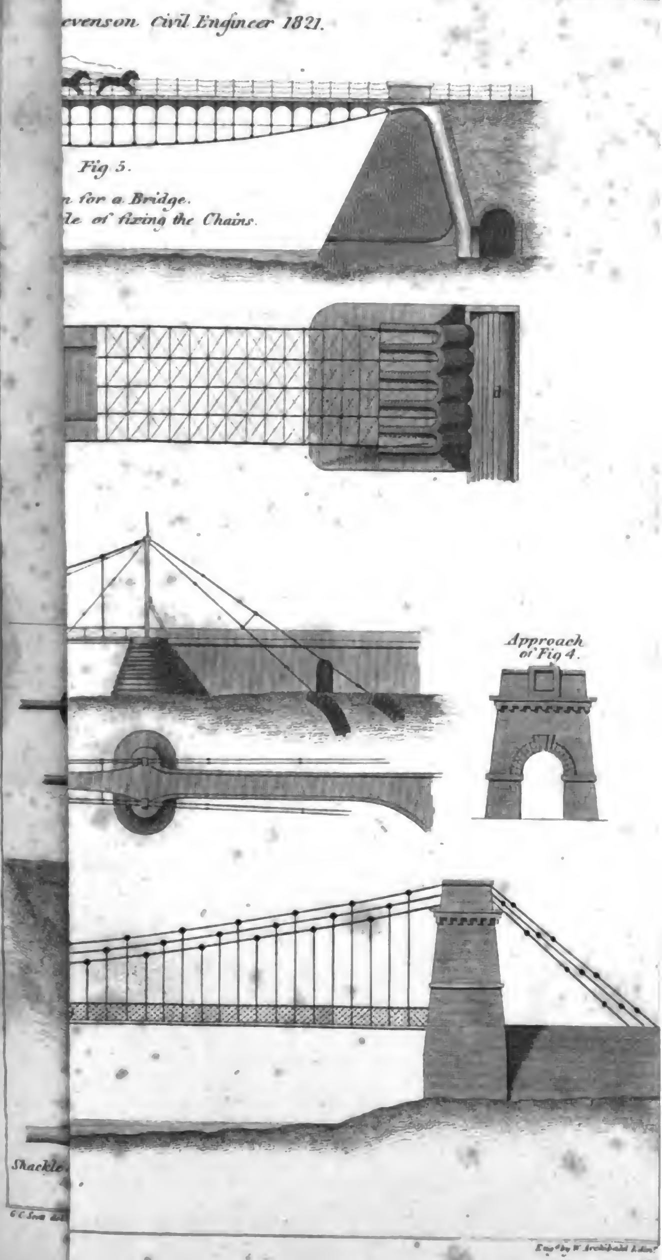

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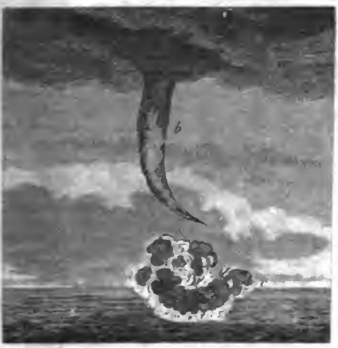

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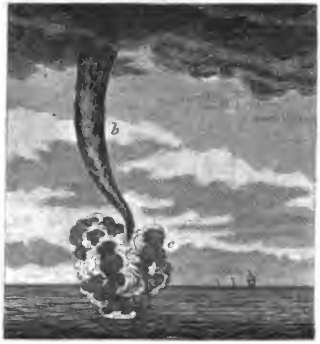

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

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PLATE X.

Fig. 1.

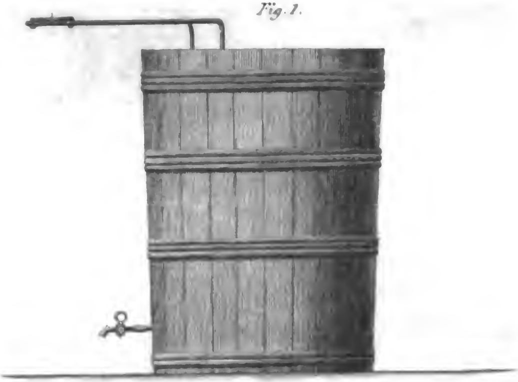

Fig. 2.

Fig. 3.

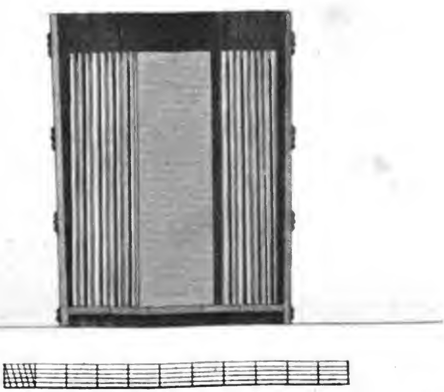

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Fig. 1.

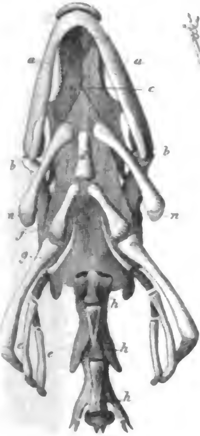


Fig. 2.

Fig. 3.

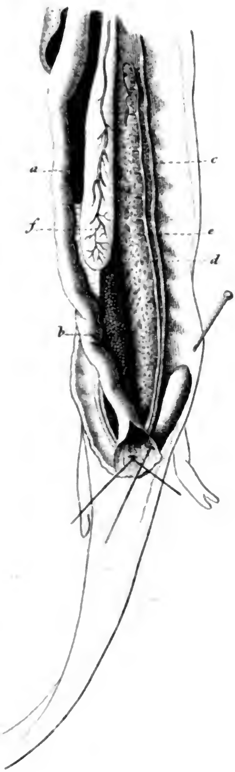
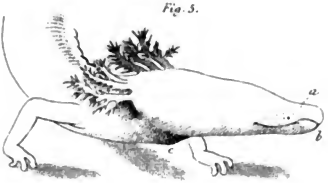


Fig. 4.

Fig. 5.



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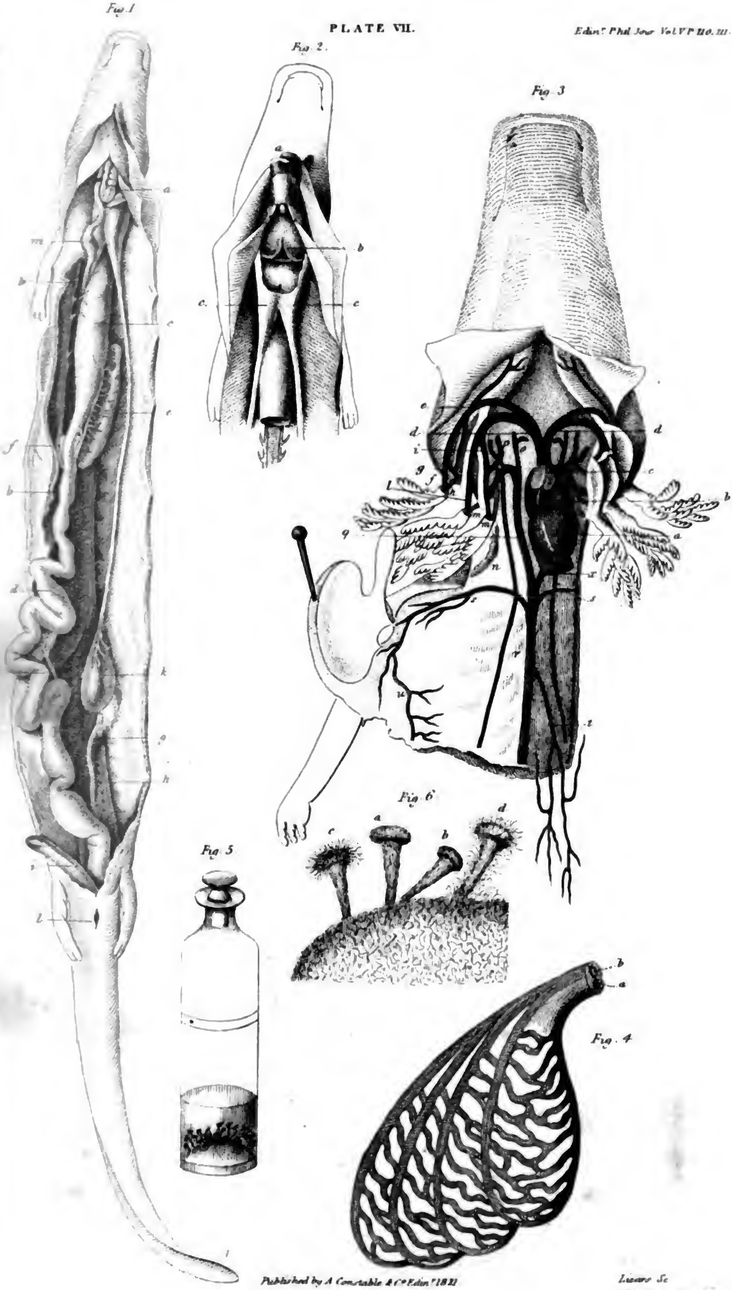

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Lizars Sc.

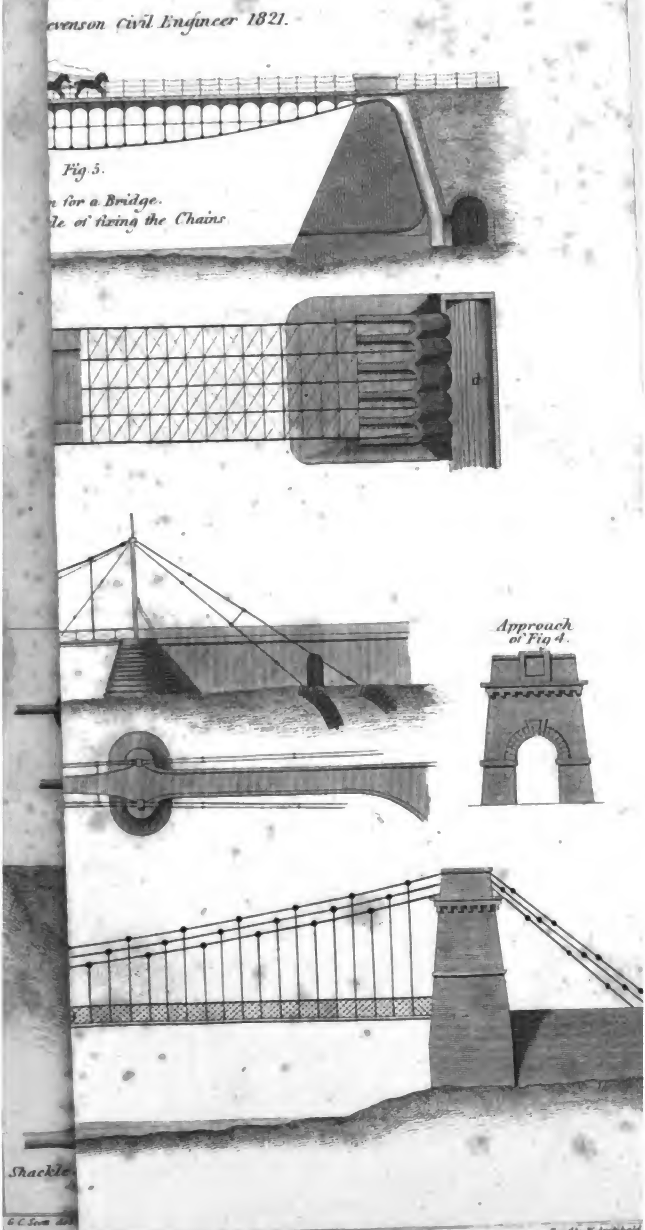
evenson Civil Engineer 1821.
Fig. 5.
n for a Bridge.
le of fixing the Chains
Approach of Fig 4.
Shackle
G. C. Scott del.
Engd by W. Archibald

PLATE IX.

Fig. 1.

Fig. 2.

Fig. 3.

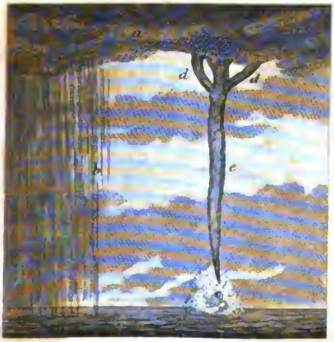

Fig. 4.

Fig. 5.

Fig. 6.

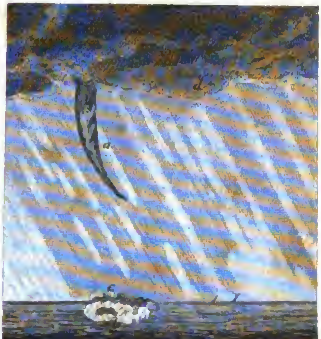

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PLATE X.

Fig. 1.

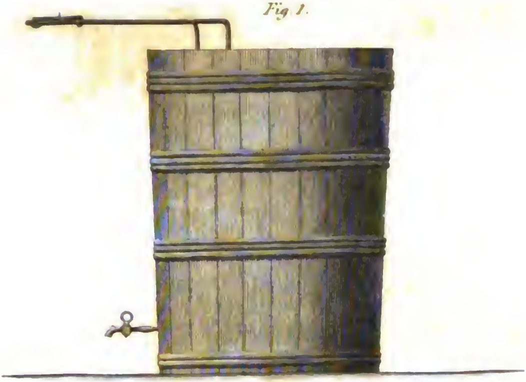
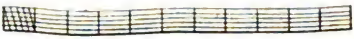


Fig. 2.

Fig. 3.



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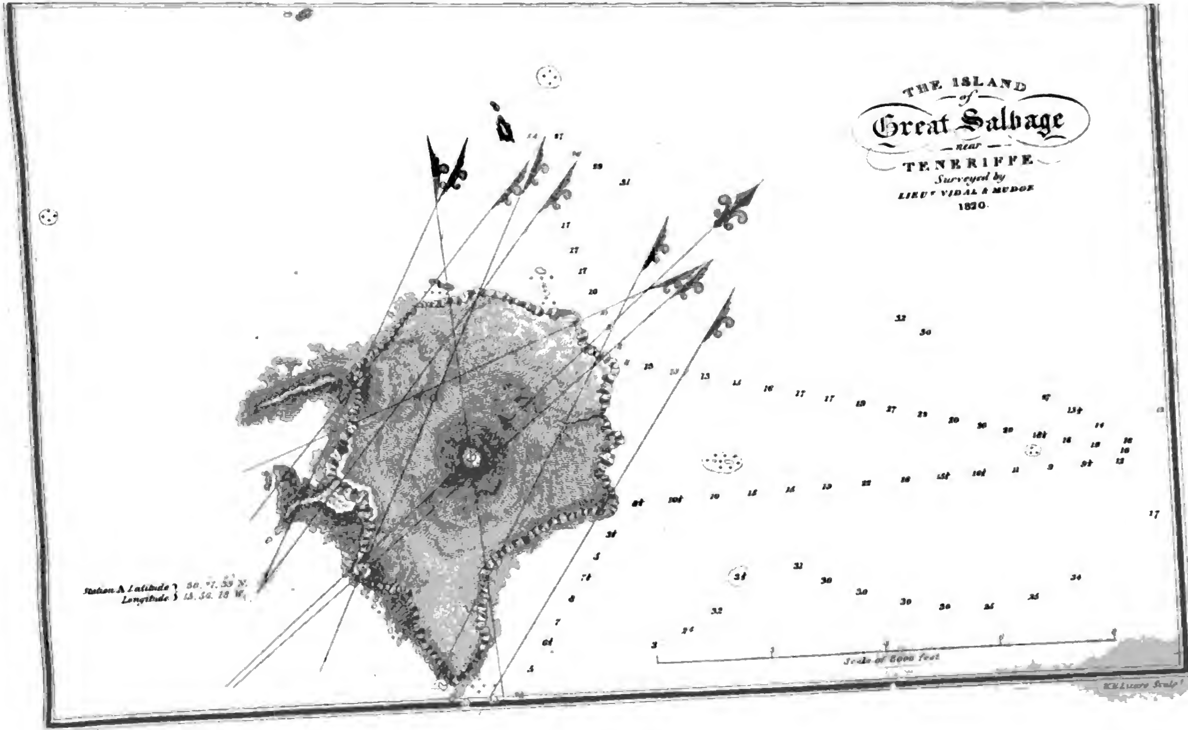
THE ISLAND
of
Great Salvage
near
TENERIFFE
Surveyed by
LIEUT. VIDAL & MUDGE
1820.
Station A Latitude 30. 7. 53 N.
Longitude 15. 56. 18 W.
Scale of 6000 feet